TEXTBOOK OF PHARMACOGNOSY

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By

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WITH 213 ILLUSTRATIONS

LONDON

J. & A. CHURCHILL Ltd.

104 GLOUCESTER PLACE
PORTMAN SQUARE

1946

PREFACE

About eight years ago Messrs. J. and A. Churchill invited me to write a new work on pharmacognosy that would give a modern presentation of the subject. At the same time the publishers suggested that I might use any figures or other material from the textbook of the late Professor H. G. Greenish, and I have made full use of the permission thus given me and have obtained much assistance from that source.

In writing this book, it has been my aim to avoid any tendency to produce an encyclopædic treatise or one having the character of a dictionary of *materia medica*, but to develop the subject by a logical application of scientific principles. This outlook has necessitated a considerable rearrangement of subject-matter and a deferment of discussions of general principles to the end of the book, when a study of details should have provided material upon which such discussions could be based.

The subject-matter of pharmacognosy is so great and varied that it is necessary to make a selection so as to keep a textbook within reasonable limits; I have therefore excluded a number of less important items, while at the same time adding a few commodities of more recent introduction and others which have regained a place in pharmaceutical practice. Details of practical work are omitted as being unsuitable for inclusion in a book giving an account of the theoretical aspect of the subject. Instructions for the practical examination of the drugs, either in the unground condition or in the form of powder, are to be found in the author's "Practical Pharmacognosy."

Particulars relating to the chemical structure of constituents of the drugs should be studied in the chemical literature, and details of processes of chemical assay will be found in the pharmacopœias and in such journals as the *Quarterly Journal of Pharmacy and Pharmacology* and *The Analyst*. A useful and interesting account of many assay processes and excellent photographic illustrations of important drugs are given in "Chemistry and Pharmacy of Vegetable Drugs," by Noel L. Allport, F.R.I.C., a book which can be recommended as supplementary to the present textbook.

Particulars relating to standards adopted for official purposes must be found by consulting the various pharmacopœias, the British Pharmaceutical Codex and other official publications, so that the reader may be acquainted with the most recent legal requirements, which are constantly undergoing revision to keep pace with the advance of knowledge and the trend of current medical and pharmaceutical practice. Habitats also should be studied by reference to a good Atlas, which may be usefully supplemented by an atlas of economic products, many of which are included in the *materia medica*

No attempt has been made to give a review of the historical development of pharmacognosy. Much information is available relative to the early practice of medicine, as also are accounts of explorations in many parts of the world, and there is much literature describing medicines used in the past. It would, however, need an expenditure

of much time and patience to assess the influence of all these factors in developing the *materia medica* of modern times. I have been unable to give adequate attention to this interesting topic and have decided to omit from the present book any summarised account of the evolution of pharmacognosy. Historical notes upon the introduction of individual drugs are given under the headings of many of the more important drugs.

Many of the illustrations are entirely new and have been specially drawn by the author. A considerable number, however, has been taken from those selected from Continental authors by the late Professor Greenish for the illustration of his book, while twelve figures are from photographs and two from drawings by Professor Greenish himself. Fourteen figures, or parts of them, are reproduced from the *Pharmaceutical Journal* and two from the *Chemist and Druggist* by permission of the respective editors. To my wife, Alice M. Wallis, I am indebted for the whole or parts of six figures and for redrawing five figures from other authors. Mr A. I. Robinson and Mr. Eldershaw have given me advice upon modern drying plant and the Sturtevant Engineering Company has kindly supplied the drawings for Figs 24 and 25. The sources of the figures are acknowledged in the legend attached to each

Dr. G B West has kindly read and criticised the articles and drawings dealing with the endocrine glands. For assistance in proof reading I am much indebted to Mr. F. Hemming and to Mr. J. W. Fairbairn for reading the galley proofs and to Mr. W. W. Binns for reading the page proofs.

T. E. WALLIS.

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PHARMACOGNOSY

CHAPTER I

INTRODUCTION

Crude drugs of vegetable and animal origin form the subject-matter with which pharmacognosy is concerned. A large number of these crude drugs, *e.g.*, Irish moss and cantharides, consist of entire plants or animals; others consist of entire members of plants or animals, *e.g.*, senna leaflets and thyroid glands; others again are substances derived from plants or animals by more or less elaborate processes of extraction, *e.g.*, catechu, aloes, opium, resins, etc. These substances, catechu, aloes, etc., are complex bodies consisting of several components occurring intimately mixed together in fairly definite proportions and are crude drugs in contradistinction to other extracted materials, such as strychnine, caffeine, strophanthin and cantharidin, which are pure chemicals and are therefore excluded from pharmacognosy as separate items of study. The constitution, molecular structure and properties of these chemical entities fall within the province of chemistry; it is only their occurrence as constituents of crude drugs and their general properties as members of classes of constituents that are included in pharmacognosy. Starch stands in a rather different position; it is not a pure chemical entity, with a definite melting point and uniform constitution; it has, on the other hand, a characteristic morphology, enabling one to distinguish between the different kinds, which are chemically similar. Hence, although starch is obtained by a process of extraction from plants and is a purified product, it is included in the subject-matter of pharmacognosy.

Other categories of substances used by the medical practitioner and by the pharmacist are also included, for example, the fibres and fabrics used for making surgical dressings; materials used as strainers for filtration or for clarifying cloudy liquids, also substances such as agar, gelatin and wax, which although used to a limited extent as remedial agents, are more largely employed as bases or vehicles for the manufacture of ointments, suppositories, lozenges and other special types of medicament or of preparations, accessory to the medical art, such as culture media and certain types of toilet article. Materials such as derris and pyrethrum, which are used chiefly for the destruction

in a wide sense, so as to include all those materials which come legitimately within the purview of pharmacy.

All the substances referred to above, together with minerals and inorganic and organic chemicals constituted the old materia medica of the medical practitioner and the pharmacist. Before the study was systematised, they were commonly described as independent units and for ease of reference were arranged alphabetically under the great

divisions of minerals, plants and animals. The earliest books containing these descriptions were known as "herbals" and the more recent ones as textbooks of materia medica. Examples of the old herbals are the "Ortus Sanitatis," 1485, by an unknown author, the "De Historia Stirpium," 1542, by Leonhart Fuchs, "A New Herball," 1551, by William Turner.

The "**Ortus Sanitatis,**" *meaning the Garden of Health, is written in* Latin and was published at Mainz in 1491. It contains an account of *materia medica from the animal, vegetable and mineral kingdoms, the* items being arranged alphabetically. The book is illustrated by rough wood-cuts, many of them copied from an *older work*, known as the

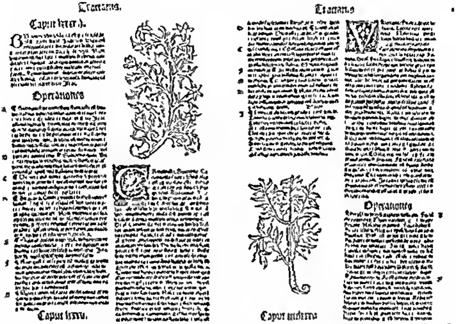

FIG. 1. Two pages from the "Ortus Sanitatis" (1517 edit.); being left-hand pages each is headed "Tractatus," i.e., treatise; the remainder of the caption, viz., "de Herbis," i.e., about herbs, is on the right-hand pages (see under Starch). The photographs sh[illegible] nnings of Chapter 85 [illegible] A rough wood-cut [illegible] *After a description,* [illegible] under the heading

"Herbarius zu Teutsch," which is a German translation made by Johan von Cube, of the Latin "Herbarius," a book of unknown authorship. The "Ortus Sa[illegible] during much of the sixteenth

[illegible] onhart Fuchs, is concerned [illegible] of the book was to provide [illegible] illustrated descriptions by which the plants used in medicine could be correctly identified. The plants are arranged alphabetically under their Latin names.

"**A New Herball,**" 1551, by William Turner. This was the *only* notable English herbal produced during the sixteenth century and the earliest English book, which gave a truly scientific account of plants [illegible] plants used as simple[illegible]

another quaint treatise known as "Ye Grete Herball" ("The Great Herbal" —a translation from a French book very similar to the "Ortus Sanitatis").

To the accounts of the drugs in the earlier textbooks of materia medica, there was gradually added an increasing amount of detail about their action and about the preparations made from them, and an arrangement of the drugs of vegetable and animal origin based upon the accepted botanical and zoological classifications was adopted by many authors. A very good example of such an elaborate treatise is that of Pereira (1839); his "Materia Medica" included a full account of physical methods of treatment—such as the application of heat and electricity—and of mineral and chemical substances, as well as of crude drugs from the animal and vegetable kingdoms. Such an encyclopædic mass of knowledge became unwieldy and beyond the power of one author to treat satisfactorily and it was eventually subdivided into sections each of which could be developed by specialists. In this way there became established the following four distinct departments of study—all dealing with drugs, but from different points of view:—

1. **Pharmaceutical chemistry,** which was developed in this country by Professor J. Attfield in a textbook which ran through about twenty editions. This subject includes the theory and fundamentals of scientific chemistry, but emphasis is focussed upon chemical substances of pharmaceutical importance.

2. **Pharmacy or Pharmaceutics,** which is concerned with the modes of treatment of chemicals and crude drugs in the preparation of galenicals and medicines in forms suitable for administration.

3. **Pharmacology or Pharmacodynamics,** under which heading are studied the responses of organisms when subjected to treatment by drugs. One may note here that the term pharmacology was formerly (up to about 1850) synonymous with the old materia medica as defined by Pereira, but has become gradually limited in meaning to pure pharmacodynamics, as this department was termed by Pereira and is still usually named in the United States of America.

4. **Pharmacognosy,** which is the scientific study of the structural, physical, chemical and sensory characters of crude drugs of animal and vegetable origin and includes also their history, cultivation and collection, and other particulars relating to the treatment they receive during their passage from the producer to the distributor or pharmacist. [illegible] *study of*

[illegible] "simple drugs," indicating that they exist as they occur naturally, not having been compounded or mixed with other substances. The term "simple" is used in the titles of books written by some of the earlier modern French pharmacognosists, who describe their books as histories of simple drugs, *e.g.*, Guibourt's "Histoire de Drogues Simples", the term "Simplicia" was used as a general heading for the same substances in the London Pharmacopœia.

In pursuing the study of a number of individual drugs, one must adopt some particular sequence of arrangement, *i.e.* one must devise

some system of classification of the materials. The simplest method of arranging a number of disconnected items is to set them out in alphabetical order, and, if there are no connecting features of a scientific nature, the alphabetical arrangement is the only possible one. This method is adopted in certain modern books, which have the form of dictionaries or encyclopædias of materia medica; a good example is Reutter's "Traité de Matière Médicale et de Chimie Végétale," Paris, 1923.

Many authors, especially the earlier ones, have utilised the classification of those other sciences, a knowledge of which is necessary before entering upon a systematic study of pharmacognosy itself. For this reason, one finds textbooks arranged according to a biological or chemical or pharmacodynamical (pharmacological) classification. Such arrangements seem to indicate that pharmacognosy is a subdivision of the science, the classification of which is adopted by the author. This, however, is a mistaken standpoint, for pharmacognosy, while utilising the information furnished by all these fundamental sciences, is itself a distinct entity. Classification proper must therefore arise out of pharmacognosy and must be based upon some fundamental characteristics which will bring drugs into large groups, each having some particular feature in common. The larger groups must be further subdivided into smaller sections by the use of other characters which apply to smaller numbers of drugs within the larger groups. For the elaboration of a helpful system of classification the type of character chosen must bear a direct relationship to the nature of pharmacognostical work. The chief functions of a pharmacognosist are five in number, namely, to identify the source of the material forming the

classification should accentuate structural similarities and differences between drugs; other features, such as chemical properties, can be included as accessory information. Such a classification is best obtained, in the case of drugs composed of plant or animal members and showing a definite cellular structure, by making groups on a morphological basis, thus bringing together similar structures such as leaves, roots, etc. For the large number of drugs which have no cellular structure and consist of such materials as dried juices, secretions or extracts, groups are obtained by using the method of preparation or the nature of the constituents or some other convenient natural connecting link between the individual drugs. Having decided upon the large groups into which the materia medica is to be divided for the study of pharmacognosy, it remains to consider the order of treatment. The sequence adopted should be as logical as can be devised, leading generally from simpler to more complex structures Not only must one consider the comparative complexity of the gross structure, but one must associate with it the microscopical structure and endeavour to combine all the factors to the greatest advantage. The series of groups selected and the sequence adopted in this book will be found set out in the Table of Contents on pp. vii–ix.

Arising out of the scientific study of drugs is the problem [illegible] structing accurate and sufficient descript[illegible] utilises all the [illegible] pure sci[illegible] details, [illegible] rapidly recognised. [illegible] of the pieces of drug; [illegible] (4) the fracture and texture; [illegible] taste; (5) [illegible] sample, by which one indicates [illegible] exhibits [illegible] anc [illegible] of [illegible] cursive [illegible] order of [illegible] is stud[illegible]

[illegible] the information concerning any given drug [illegible] naturally into sections each relating to [illegible] knowledge and [illegible] in a definite [illegible] biological a[illegible] [illegible]ety and name. (2) Cultivation [illegible] P[illegible]ation, including details of cultivation of the plant, methods of collection, drying, packing and [illegible] of the drug during its [illegible] including the [illegible] fracture, etc. [illegible] Micros[illegible] of [illegible] Con- sti[illegible] [illegible]ive constituents and also other con[illegible] which may need careful consideration when devising processes of extraction for the manufacture of galenicals or when studying compatability in dispensing practice. Chemical tests of identity are based upon the nature of the constituents (5) Evaluation. This involves quantitative measurements of two types, the first is based upon the physical characters and the second [illegible] stituents. The resulting standards [illegible] ment [illegible] etc (6) Adulterants, [illegible] fraudulently and also matter which has become associated with the drug owing to carelessness in handling during collection, packing and transport.

CHAPTER II

STARCHES

Name and History. The Latin and English names of starch both represent an epitome of history. The earliest starch was made from wheat by the Greek inhabitants of the island of Chios, off the coast of Asia Minor; the manufacture was described by the Latin writer Marcus Porcius Cato about 184 B.C. in his "De re rustica" and later by another Roman, Pliny the Elder, about A.D. 50. The name given by these authors to the white powder produced was *amylum*, which is derived from two Greek words, *a*, without, and *mylos*, a mill, indicating that the starch was made directly from the grain without the use of a mill, in contradistinction to flour, for which a mill was used. The grain was soaked in water till thoroughly softened and the magma was kneaded enclosed in a bag formed of cloth, see Fig. 2, from "Ortus Sanitatis."

FIG. 2. Page from the "Ortus Sanitatis" (1517 edit.) showing Chapter 24 on Starch. The wood-cut shows the primitive process of manufacture.

During the Middle Ages (A.D. 500–1500) the manufacture became an important Dutch industry and the starch was used chiefly for stiffening fabrics, especially for the use of the nobility and higher ecclesiastics. Starch began to be made in England during the reign of Queen Elizabeth (1558–1603), who had a special court official for laundry starching. It is from this use of starch that the English

variant of

ing starch continued until about A.D. 1700 and, since wheat was the staple source of human food, many enactments were made to regulate the manufacture. At times it was entirely forbidden and at other times permitted under supervision, or a charter was granted to some special corporation enabling it to manufacture starch from specified types of grain unfit for human food. During the eighteenth century search was therefore made for other and cheaper sources of

sources of starch were tried, such as horse chestnut seeds and corms of *Arum maculatum*, but no appreciable quantity of starch was ever made from them.

About 1800 starch began to be manufactured in the United States of America from maize, and this plant is the source of the greater part of starch of modern times. Rice came to be used on a large scale about 1850 and still forms an important source of starch.

Sources. Starch is the most common carbohydrate reserve and is

found in varying amounts in almost all plant members, in somo of which it is merely transient while in others it is stored in quantity for future use. Starch is always extracted from those members of plants which contain reserve food stores, because these are the only parts in which starch accumulates in sufficient quantity to make its extraction a commercially economic process. Different plants often utilise different plant members for the storage of reserve starch and consequently, in the preparation of commercial starches, many different parts of plants are used as the raw material. For example, sago is derived from tho stems of the palms *Metroxylon sagus* and *M. Rumphii* and Florida arrowroot from tho stem of a cycad, *Zamia floridana*; potato starch from the tubers of *Solanum tuberosum*; tapioca and cassava starch from the enlarged roots of *Manihot utilissima* and *Dioscorea alata* respectively, arrowroot from the rhizomes of the West Indian *Maranta arundinacea* and tho East Indian *Curcuma angustifolia* and *C. leucorhiza*, wheat, maize and rice starches from tho fruits of cereals and pea and bean starches from the seeds of leguminous plants. The methods used for tho extraction of the starch vary according to the structure and composition of the raw material and details are given under the individual starches.

Wheat starch is manufactured chiefly in Germany and Czechoslovakia; maizo starch in tho United States of America, Canada, Great Britain and Germany; rice starch in Britain, Holland and Belgium; potato starch chiefly in Germany.

Manufacture of Starch. Of tho common cereal starches, wheat starch is made from flour, maizo starch from tho entire fruits and rico

. . tho prepara-

omposition of

	Moisture	Proteins	Fat	Starch	Fibre	Ash
Wheat flour .	8 to 15	9 to 15	0 5 to 1 5	65 to 70	0 1 to 1 0	0 3 to 0 8
Maize .	9 to 14	12 6	4 3	60 to 65	2 0	1 7
Broken rice	10 to 14	6 to 9	0 4 to 0 8	70 to 78	0 3 to 1 0	1 to 2
Potato . .	76	1 9	0 1	20 1	1 to 4	2 to 6

In the case of wheat and rice tho preliminary milling processes have removed the embryo and bran, while both these structures are present in the fruits of maize. Other points to notice are that tho starch granules in wheat, potatoes and arrowroot rhizomes lie loosely in the cells, while in maize and rice they are closely packed and agglutinated together; the separated protein also varies much in character, being glutinous and adherent in wheat, while it is non-adherent in maize. From these considerations it is evident that the processes used for the manufacture of the different starches must vary considerably in detail according to the nature of the raw material.

Manufacture of Wheat Starch. Wheaten flour (from the grains or fruits of *Triticum æstivum* Lam., family Gramineæ) is made into a dough by mixing it with 40 per cent. of its weight of water and is allowed to stand for an hour to permit tho gluten to swell. The dough is made into lumps, each weighing several pounds, and the starch is

washed out on a machine consisting of a grooved roller which works to and fro over a fixed horizontal board, flanked by sieve surfaces. During this mechanical kneading, the dough is continually sprinkled with water which carries the starch into a collecting trough while the gluten remains as a soft, yellowish-grey mass. The starch is commonly separated by spinning the liquors in centrifuges having imperforate drums; the large granules collect against the drum as a compact layer of comparatively pure starch and a softer layer of glutinous starch forms upon the inside, while in the centre is a liquid containing a small amount of very fine starch and gluten. The liquid is drawn off, the glutinous starch removed by scraping and the compact white starch reserved. The glutinous starch is purified by allowing it to ferment for a week or two, thus effecting a partial degradation, and solution of the gluten, and the starch is removed by washing and sedimentation.

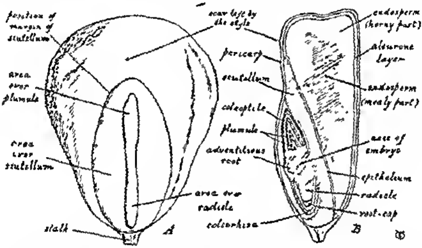

Fig. 3. Fruit (caryopsis) of *Zea Mays* Linn. *A*, broad surface showing the external features. *B*, longitudinal section through the embryo. Both × 3.

The starch is finally dried on trays, about 5 × 3 ft., made of canvas stretched on a wooden frame and each holding from 4 to 8 lb. of starch. The trays are arranged in stacks and heated air is circulated over them; the drying takes about twenty-four hours and the product is lump starch. The lumps are powdered in special mills and sifted through a fine silk cloth. The **wheat gluten** obtained as a by-product commands a higher price than the starch and is used as an addition to fodders and foodstuffs, as a thickening agent in textile printing and in diabetic dietaries.

Manufacture of Maize Starch. To prepare starch from maize (the grains or fruits of *Zea Mays* Linn., family Gramineæ) processes must be devised to remove bran, aleurone, embryo and oil, and the cellulose walls of the endosperm, see Fig. 3. Grains of maize are steeped for two to four days in water at 40° to 60°; after the first one or two changes of plain water, which remove dirt, about 0·3 per cent. of sulphur dioxide is added to the water. The steeped maize is passed between rollers which split and partially crush the grains; this liberates much starch

and detaches the embryos from the remainder of the grains. The material is transferred to a "degerminator," which is usually a V-shaped trough with a screw-conveyor along the bottom. This

through a No. 90 shaking-sieve and the coarse solid matter left on the sieve is ground in stone mills and then pumped on to the sieves to remove more of the starch; the residue on the sieves is chiefly bran and gluten. The combined liquors from the sieves are passed over finer shaking-sieves, about No. 160, which remove some fibrous and glutinous matter. The liquor from these sieves is concentrated by sedimentation and is then allowed to flow at a rate of about 4 to 8 in. per second over depositing tables or runs, which are troughs of wood or cement about 120 ft. long by 1 or 2 ft. wide and 6 to 8 in. deep, with a fall of about 4 in. in the entire length. The starch settles on the tables and the liquors flowing away contain fibre and gluten and a small amount of fine starch which it is uneconomical to recover. The deposited starch has associated with it about 50 per cent. of water and 0·5 per cent. of protein. A second tabling will reduce the protein to 0·3 per cent., sometimes very dilute caustic soda is used to aid this final purification. The damp starch is drained in perforated, cloth-lined moulding boxes, about 5 ft. × 9 in. × 9 in., until the moisture-content is about 44 per cent., after which it is made into cubes of 7 to 8 in. edge and transferred to warm "crusting kilns" where the surface becomes brownish to a depth of ⅛ to ¼ in. The crust is scraped off and the residue is powdered in specially constructed mills and sifted through a fine silk cloth.

The embryos which are removed during the process are dried to about 4 per cent. moisture and are pressed to yield maize oil which is used for soap making; the maize germ cake obtained after the expression of the oil is a valuable feeding stuff containing about 21 per cent. of protein and 13 per cent. of oil.

Manufacture of Rice Starch. About 8 parts of broken rice (the fruits of *Oryza sativa* Linn., family Gramineæ) are steeped in about 16 parts of a 0·4 per cent. solution of caustic soda; the mass is stirred every six hours and the liquor changed every eighteen to twenty-four hours; the process is complete when the grain can be crushed between the fingers. This treatment loosens and partially dissolves the glutinous matter which holds the starch granules together. The steeped rice is ground in a stone mill with 2 parts of the dilute soda to each part of the steeped rice and a milky fluid results which contains about 25 per cent. of solids. This starch suspension may be diluted until it contains about 2·5 per cent. of solids and then allowed to settle in vats or it may be treated in centrifuges for the removal of the starch. The thick starch suspension is put into cloth-lined boxes, about 5 ft. long × 9 in. × 9 in., having perforated bottoms and allowed to drain, the boxes being filled up with more of the suspension as the mass contracts. The damp starch, containing about 44 per cent. of water, is cut into cubical blocks and transferred to a crusting-oven at 50° to

alcohol, ether, acetone, etc., it is also insoluble in cold water, but it rapidly sinks in water owing to its high density, which varies from 1·62 to 1·65.

The fact that starch has a **density** of about 1·6 may be utilised for the separation of starch from **mixtures** such as baking powders and also for the detection of small quantities of **impurities** such as sand or crystals of calcium oxalate, which are found in starches prepared from stems of cycads, such as *Zamia floridana* A.DC., which is the source of Florida arrowroot.

The separation is effected by sedimentation or by centrifugation in an indifferent fluid having a density intermediate between that of the starch and of the material to be separated. Chloroform, bromoform and mixtures of the two are often used for this purpose.

It should not impart more than a very slight reaction to water, wheat and potato starches being usually faintly acid while rice starch is faintly alkaline and maize starch is usually neutral, although some inferior varieties are sometimes faintly alkaline. Air-dry starch obtained from wheat, maize or rice contains on an average about 13 per cent. of moisture, arrowroot contains about 14 to 17 per cent. of moisture and potato starch about 18 to 20 per cent. Starches are markedly hygroscopic and will absorb water until the amount present is about 35 to 37 per cent. Treatment with boiling water causes the gelatinisation of starch and a cloudy viscous fluid, described as mucilage of starch, results. The viscosity of the mucilage formed depends upon the variety of starch used and upon the time for which the fluid is heated, a maximum viscosity being attained after a certain time which is different for each starch and further heating results in a decrease of viscosity. The following data are compiled from the work of Harrison (1911).

Starch	Maximum viscosity Water = 1	Time to attain maximum viscosity
Wheat	1·3	35 minutes.
Rice . . .	2·34	35 to 60 minutes
Maize . .	3·5	6 hours.
Potato	23 to 65	10 to 15 minutes

The above figures relate to a 1 per cent. mucilage made by taking

determined ; it has been variously regarded as a mixture or a compound of starch and iodine, and more recently as being iodine adsorbed by the starch. The amount of iodine adsorbed in the presence of an excess of iodine is a constant and is used by some workers as a means of determining starch quantitatively. The weight of starch iodide multiplied by the factor 0·8865 (Chinoy, Edwards and Nanji, *Analyst*, 59 (1934), 673) gives the amount of starch precipitated as iodide.

Constituents of Starch. Starch consists of two or three chemically individual substances, all closely related to the sugars, distributed throughout the body of the starch granule in different physical states. The important constituents are polymerised amylose, amylopectin and amylo-hemicellulose; the two first are present in all starches, while the third is found in notable quantities in certain starches only, such as those derived from graminaceous seeds. *Polymerised amylose* has as its basal unit α-hexa-amylose, an α polysaccharide related to maltose and a suggested formula is $[(C_6H_{10}O_5)_2]_3$; this constituent is soluble in water. *Amylopectin* is a phosphoric ester of the polysaccharide αβhexa-amylose; it forms a gelatinous material with water and is the constituent which imparts the gelatinising property to starch. *Amylo-hemicellulose* is the calcium-magnesium or iron-salt of a silicic ester of a polysaccharide and appears to be absent or almost absent from certain starches, such as those of potato and arrowroot. The polymerised amylose and amylopectin are present in all starches in the proportion of about two of the former to one of the latter. Twenty-five per cent. of the polymerised amylose exists as a crystalloid phase in the form of sphærites constituting a core round the hilum of the granule and is readily extracted by water or by dilute alkali. The remainder of the amylose is in the colloidal phase dispersed uniformly in the amylopectin layers, it appears to exist in a solid solution or so strongly adsorbed on the amylopectin as to resist extraction (see Ling and Nanji, J.C.S. 1923 T, p. 629).

Structure of Starch. Structurally starch consists of colourless and highly refractive granules (refractive index about 1·5) which are microscopical in size—not exceeding 150 microns in maximum dimension—and possess definite morphological characters which are evident under the microscope as a hilum and striations or concentric rin[illegible] lighter point according as [illegible] varied, is the part of the [illegible]. The hilum is not always distinguishable, especially in very small granules; when evident it may be placed centrally or may be nearer one end than the other, *i.e.* eccentric. The end of the granule, nearer to which the hilum is situated is frequently termed the "proximal" end, while the end further away is the "distal" end. The degree of eccentricity of the hilum is recorded as a fraction, *e.g.* $\frac{1}{1}$ or $\frac{1}{3}$ or $\left(\frac{1}{1} \text{ to } \frac{1}{3}\right)$ etc., the numerator and denominator of the fraction representing respectively the proportional distances from the hilum to the proximal and distal ends of the granule. The striations or concentric rings are fine lines surrounding the hilum or, in the case of granules showing a marked eccentricity, forming parallel arcs traversing the granules more or less transversely; [illegible] of starch granu[illegible] as shell-like en[illegible] not quite unifo[illegible] or colloid, and in moisture content; they therefore possess different refractivities, so producing the appearance of fine concentric rings.

Both the hilum and the striations are more clearly seen in com-

mercial starches than in granules observed *in situ* ... This is due to the ... and to the ... during the ... starches are subjected during their preparation for the market. As a consequence the hilum often becomes replaced by a hollow or ...

... crossed nicols, starch ... appear as luminous objects on a black background, some starches, such as potato, being more brilliant than others, such as wheat. Another appearance produced by the polarised light is a cross composed of black lines ... If the nicols are rotated th... while the granules are d... ...cross. Further brilliant effects can be produced in polarised light by the use of a selenite plate, which is placed under the slide carrying the starch. The field then appears uniformly coloured, the most usual colour being red or blue, and the starch granules show four regions similar in form to those marked out by the cross seen in ordinary polarised light, but two are coloured red or blue, *i.e.*, the same colour as the field, and the other two alternating with them are coloured with the complementary tint, viz., green or orange. The whole of the colours change to the complementary ones when the analyser is rotated. For observation of the effects of polarised light, a highly refractive mountant should be used; Canada balsam is suitable for permanent mounts and lactophenol for temporary ones. Examination in polarised light is particularly useful when one wishes to identify granules as starch, without subjecting them to the action of any chemical reagent.

The behaviour of starch towards *water* is of considerable microscopical interest. Air-dry starch contains about 11 to 20 per cent. of moisture and is capable of absorbing much larger am... to about 35 to 37 per cent. ... a very slight swelling in ... Starch which has been ... temperature ...

to ... wil... of ... is immers...

... ...elongated and twisted granules of these forms, see Fig. 4. Gelatinised granules are present in sago and tapioca and also in such drugs as jalap, turmeric, etc. As starch granules swell under the action of heated water, they lose their power of affecting polarised light.

Constituents of Starch. Starch consists of two or three chemically individual substances, all closely related to the sugars, distributed throughout the body of the starch granule in different physical states. The important constituents are polymerised amylose, amylopectin and amylo-hemicellulose; the two first are present in all starches, while the third is found in notable quantities in certain starches only, such as those derived from graminaceous seeds. *Polymerised amylose* has as its basal unit α-hexa-amylose, an α polysaccharide related to maltose and a suggested formula is $[(C_6H_{10}O_5)_2]_3$; this constituent is soluble in water. *Amylopectin* is a phosphoric ester of the polysaccharide αβhexa-amylose; it forms a gelatinous material with water and is the constituent which imparts the gelatinising property to starch. *Amylo-hemicellulose* is the calcium-magnesium or iron-salt of a silicic ester of a polysaccharide and appears to be absent or almost absent from certain starches, such as those of potato and arrowroot. The polymerised amylose and amylopectin are present in all starches in the proportion of about two of the former to one of the latter. Twenty-five per cent. of the polymerised amylose exists as a crystalloid phase in the form of sphœrites constituting a core round the hilum of the granule and is readily extracted by water or by dilute alkali. The remainder of the amylose is in the colloidal phase dispersed uniformly in the amylopectin layers, it appears to exist in a solid solution or so strongly adsorbed on the amylopectin as to resist extraction (see Ling and Nanji, J.C.S. 1923 T, p 629).

Structure of Starch. Structurally starch consists of colourless and highly refractive granules (refractive index about 1·5) which are microscopical in size—not exceeding 150 microns in maximum dimension—and possess definite morphological characters which are evident under the microscope as a hilum and striations or concentric rings. **The hilum,** which appears as a darker or lighter point according as the focussing adjustment of the microscope is varied, is the part of the granule that was first formed in the plastid. The hilum is not always distinguishable, especially in very small granules; when evident it may be placed centrally or may be nearer one end than the other, i.e. eccentric. The end of the granule, nearer to which the hilum is situated is frequently termed the "proximal" end, while the end further away is the "distal" end. The degree of eccentricity of the hilum is recorded as a fraction, *e.g.* $\frac{1}{1}$ or $\frac{1}{3}$ or $\left(\frac{1}{1} \text{ to } \frac{1}{3}\right)$ etc., the numerator and denominator of the fraction representing respectively the proportional distances from the hilum to the proximal and distal ends of the granule. **The striations** or concentric rings are fine lines surrounding the hilum or, in the case of granules showing a marked eccentricity, forming parallel arcs traversing the granules more or less transversely; they result from the stratified [illegible]

not quite uniform in composition, in physical condition, *e.g.*, crystalloid or colloid, and in moisture content; they therefore possess different refractivities, so producing the appearance of fine concentric rings.

Both the hilum and the striations are more clearly seen in com-

mercial starches than in granules observed *in situ* in the plant cells. This is due to the distribution of the starch constituents in the granule and to the removal of the crystalloid part of the polymerised amylose during the prolonged washing, to which starches are subjected during their preparation for the market. As a consequence the hilum often becomes replaced by a hollow or fissure which may be simple or stellate and the clearer appearance of the striations appears to indicate that the amylose in the amylopectin layers is also partly removed.

When examined by ***polarised light***, using crossed nicols, starch granules appear as luminous objects on a black background, some starches, such as potato, being more brilliant than others, such as wheat. Another appearance produced by the polarised light is a cross composed of black lines intersecting at the position of the hilum. If the nicols are rotated through a right angle the field becomes bright while the granules are dark with a bright cross. Further brilliant effects can be produced in polarised light by the use of a selenite plate, which is placed under the slide carrying the starch. The field then appears uniformly coloured, the most usual colour being red or blue, and the starch granules show four regions similar in form to those marked out by the cross seen in ordinary polarised light but two are coloured red or blue, *i.e.*, the same colour as the field, and the other two alternating with them are coloured with the complementary tint, *viz.*, green or orange. *The whole of the colours change to the complementary ones when the analyser is rotated.* For observation of the effects of polarised light a highly refractive mountant should be used. Canada balsam is suitable for permanent mounts and [illegible] for *temporary ones*. *Examination in polarised light is particularly useful* when one wishes to identify granules as starch without subjecting them to the action of any chemical reagent.

The behaviour of starch towards water is of [illegible] interest. Air-dry starch contains about 11 to 20 per cent. [illegible] is capable of absorbing much larger amounts, up to about 35 to 37 per cent., [illegible] that starch granules [illegible] cold water owing to the little absorption [illegible]. Starch which has been dried at 100° C. produces an appreciable rise in temperature when added to water. When warmed with water, starch granules [illegible] from their original size and at the same time [illegible] and ultimately burst, the process being termed gelatinisation. These changes can be observed in a general way [illegible] water and warm[illegible] to about the centre of the cover-glass, [illegible] will show granules in all stages [illegible] [illegible]

and the temperature at which they cease to exhibit the characteristic cross is named the *gelatinisation temperature*. This temperature has been found to vary with the botanical source of the starch and it has been attempted to use this datum as a means of distinguishing the different starches; the

FIG. 4. Starch of wheat (*Triticum sativum*) partially gelatinised by heating to 80° C. for four hours. × 200.

differences, however, are not sufficiently marked to enable one to do this successfully. Some of the temperatures recorded are given in the accompanying table:—

Starch	Gelatinisation temperature in °C	Starch	Gelatinisation temperature in °C
Wheat . . .	64 to 65·5	Pea (*Pisum sativum*)	68 to 74
Rice . . .	74·75	Ginger, Jamaica .	82 to 86
Maize . .	62·25 to 71	Ginger, Cochin .	90
Potato . . .	66	Sorghum . .	67 to 70
Maranta . . .	71·5 to 77		
Oat . . .	63		
Bean (*Vicia Faba*) .	65		

Gelatinisation may also be induced at ordinary temperatures by using saturated solutions of certain salts, such as calcium chloride or by acids and alkalies. The gelatinisation produced by a cold 0·9 per cent. solution of caustic potash or 0·64 per cent. solution of caustic soda is used to distinguish starch of potato from that of maranta, since the latter shows no marked alteration while the largest granules of potato starch are gelatinised at once, the medium sized ones after a short interval and the smallest show an enlargement of the hilum. In a similar way rye starch can be identified in admixture with wheat starch, since granules of rye starch are gelatinised at once while those of wheat starch show no immediate change, though swelling commences after a short time. In making such observations, standard starches should be used for purposes of comparison.

In any particular starch the variations shown by each feature of the granules are large; they are, however, confined within limits for each plant, and although some granules of one starch may be visually indistinguishable from certain of another starch, the sum of the

characters, including behaviour towards reagents and polarised light, is usually sufficient to characterise the starch derived from a single species of plant.

Maize starch consists of granules that are fairly uniform in size, measuring 5 to 25 microns[1] (μ), mostly 10μ to 15μ in diameter; they are polyhedral with blunt angles or more or less rounded. In the centre there is often a small cleft, or two or three radiating from a centre—the position of the hilum. It contains amylohemicelluloses in addition to polymerised amylose and amylopectin. Commercial maize starch is usually neutral, but some samples give an alkaline reaction. The granules are simple and number about 790,000 per mg. of the air-dry commercial starch. The moisture content is about 13 per cent. See Fig. 5.

Wheat starch consists of larger granules about 15 to 50 microns in diameter and smaller granules about 6 to 7 microns; granules of intermediate size are few. The larger granules are lenticular and the hilum appears as a central point or, when the granules are on their edges, as a line. The largest granules present measure from 40 to 50 microns, but there are very few over 45 microns. The number of granules per mg. of the air-dry starch measuring 40 microns and over is about 450, and this is an important figure because it distinguishes wheat starch from barley starch which contains no granules larger than 39 microns. In addition to amylose and amylopectin wheat starch contains 10 per cent. of amylohemicellulose. See Fig. 5.

Rice starch consists of minute grains, averaging about 6μ in diameter. They are polyhedral, with sharp angles, and without evident concentric striæ; a hilum is visible in the larger granules. Compound granules are present and consist of from 2 to 150 components; they are rare in commercial starch because they become broken into individual granules during the process of preparation. The average number of granules per mg. of the air-dry commercial starch is 10,500,000 and the moisture content is about 12 to 15 per cent. In addition to amylose and amylopectin rice starch contains 20 per cent. of amylohemicellulose. Commercial rice starch is usually alkaline in reaction. See Fig. 5.

Potato starch is used as a disintegrant in making medicinal tablets. It is also extensively employed for various technical purposes. It is the variety of starch which is preferred for use in chemical testing. The granules are flattened-ovoid or subspherical; the ovoid ones are 30-45-70-100 microns and the rounded ones 10 to 35 microns in diameter; a few of the granules are compound, with two or three components. The hilum is a point at the narrower end of the granule; concentric striations are well marked. Commercial potato starch is usually neutral in reaction and is graded according to the size of the granules, the more esteemed varieties being those which contain a greater proportion of the large granules. This starch consists almost entirely of polymerised amylose and amylopectin. The number of granules per mg. of the air-dry starch is about 73,000 and the moisture content is about 20 per cent. See Fig. 5.

[1] A micron is the one-thousandth part of a millimetre.

Maranta starch, obtained from the rhizomes of *Maranta arundinācea* Linn, family Marantaceæ, is known in commerce as St. Vincent, Bermuda, and Natal arrowroot, or simply as arrowroot, but as the latter term is applied to a number of other starches, it is desirable that this, the arrowroot of English commerce, should be specified as maranta starch. Thus the starch of *Curcuma angustifolia* Roxburgh, and *C. leucorhiza* Roxburgh, family Zingiberaceæ, is known as East Indian arrowroot; that of *Manihot utilissima* Pohl, family Euphorbiaceæ, and that of *Ipomœa Batatas* Choisy, family Convolvulaceæ, as Brazilian arrowroot; that of *Canna edulis* Edwards, and other species of *Canna*, family Cannace, as Queensland arrowroot, etc.

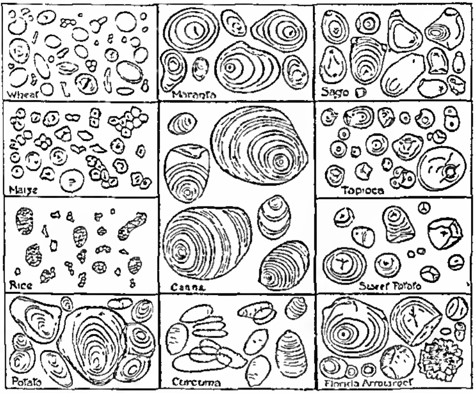

FIG. 5 Some starches of commerce. All × 200.

The granules of maranta starch are ovoid with a few small tuberosities; the striations are concentric and rather indistinct; the hilum is usually at the broader end of the granule and is represented in commercial starch by a split which usually has the form of two radiating, curved lines. They are 7 to 30 to 45 to 75 microns in diameter and are all simple. They are composed of polymerised amylose and amylopectin only. See Fig. 5.

Curcuma starch, from the rhizomes of *C. angustifolia* Roxburgh, and *C. leucorhiza* Roxburgh, family Zingiberaceæ, is known as East India arrowroot and is largely used in India, although it does not find its way, to any great extent, to this country.

The granules are flattened rectangular ovoid with a slight projection at one end; the striations are numerous, transverse and indistinct;

the hilum is a point in the terminal projection. They are 15 to 30 to 60 to 140 microns long by 25 to 35 microns wide and 7 to 8 microns thick. See Fig. 5.

Tapioca consists of the partially gelatinised starch from the rhizomes of *Manihot utilissima* Pohl, family Euphorbiaceæ; the moist starch is either raked on heated plates (*flake tapioca*) or pressed through a sieve and heated (*seed, pearl, bullet pearl tapioca*)

Sago is similarly prepared from the starch from the stem of *Metroxylon Rumphii* Martius, or *M. Sagu* Rottboell, family Palmæ. Substitutes may be prepared from other starches, such as potato, etc. Both tapioca and sago starches consist of granules, the majority of which were originally compound, but have become largely broken into single granules during the process of manufacture. Granules of *sago* starch are 20 to 55 to 65 microns in diameter, and of *tapioca* starch about 15 to 25 to 35 microns. Both starches show many muller-shaped granules, but sago starch granules are more ovoid in shape, while those of tapioca frequently show a circular outline. See Fig. 5

Soluble starch is starch altered by treatment with dilute hydrochloric acid which breaks down the amylopectin and amylohemicellulose of the starch and consequently the gelatinising property of the starch disappears. The older method (1886) of preparation is known as Lintner's method and consists in treating starch, usually potato starch, with a 7·5 per cent. aqueous solution of hydrochloric acid at the room temperature for seven days. The residue carefully washed and dried is soluble starch; it contains small amounts of amylodextrin, erythrodextrin and copper-reducing substances. A more modern method of preparation (1919) is known as Small's method; 20 gm. of starch are heated for ten minutes under a reflux condenser with 100 millilitres of alcohol (95 per cent) containing 0·75 mil. of hydrochloric acid, the mixture being constantly agitated. The contents of the flask are neutralised by the calculated amount of a solution of sodium bicarbonate, the residue is filtered out, washed with ethyl alcohol and dried.

Soluble starch is insoluble in cold water, but forms a limpid fluid with boiling water. When examined microscopically it shows the structure of the starch from which it is prepared It should be free from all but very small traces of acid or alkali and contains only traces of reducing substances and of chlorides, the moisture present is about 15 per cent

Dextrin is usually made from potato starch and is prepared either by a process of simple roasting or by roasting the starch with a very small proportion of acid. When roasted alone, the starch is continuously stirred mechanically in pans for two hours or more at a temperature of about 150° to 250° C. until the desired degree of colour and solubility is obtained; it is then cooled, dried and sifted. When acid is used, the process of dextrinisation is more rapid and the temperature used is lower The starch is mixed with dilute hydrochloric or nitric acid, about 0·2 to 0·25 per cent., by injecting the acid into a drum, in which the starch is agitated It is then dried, ground and sifted and is fed into the roaster, in which it is heated for one or two hours at a temperature of 100° to 125° C The roasting is often carried out in an oil-jacketed cast-iron vessel, so that the temperature may be carefully regulated. The amount of change is controlled by determining the solubility of the product in cold water. There are many different varieties of commercial dextrin, differing in colour and in solubility according to the rate of heating, the temperature used and the rate of cooling during manufacture Two common com-

mercial forms are yellow dextrin, which is almost completely soluble, and white dextrin, which is only partially soluble in cold water and, during preparation, is cooled as rapidly as possible after the roasting process is completed. Pure dextrin gives a reddish colour with solution of iodine and does not reduce Fehling's reagent. The commercial dextrins contain small amounts of reducing substances or of almost unaltered starch closely resembling soluble starch.

CHAPTER III

POWDERS OF NATURAL OCCURRENCE

LYCOPODIUM.

Sources. Lycopodium consists of the spores of the common clubmoss,

Cumberland; the drug is collected chiefly in Russia (Ukraine) and in Poland.

Collection and Preparation. The clubmoss is a procumbent plant with ascending tips and the slender stems, which are from 30 to 60 cm. in
moss-like leaves, each about 4 to 6
The sporo-bearing branches rise
to cones being slender, about 2 5 to
In *July and August the cones are*

that floats when thrown on to the surface of water. Blown into a flame it burns instantly
it is slowly consu
very resistant to
The drug is odourless and tasteless and devoid of grittiness when rubbed between the fingers.

Microscopy. Each spore is tetrahedral and has the shape of the fourth part of a sphere; three faces are flat and triangular while the fourth is
edges is about
25 microns.
See Fig. 5.
rk of raised
ridges forming meshes which are four- to six-sided and produce a honey-combed appearance. The three flat faces are similarly covered except towards the apex of the spore where they are nearly smooth, strong ridges mark the lines of union of the three flat faces. When strongly crushed, the spores burst and droplets of yellowish fixed oil are liberated.

Constituents. The spores contain about 40 to 50 per cent. of fixed oil, which consists principally of the glycerides of lycopodium-oleic acid (80 *per cent.*) and *myristic acid* (about 2 per cent.) Lycopodium-oleic

per cent. of ash. The moisture present is about 5 per cent

Uses. Lycopodium is sometimes used as a dusting powder for excoriated surfaces, for preventing the mutual adhesion of pills and for making snuffs (insufflations). It is also used as a standard of reference in quantitative microscopy. The greater part of lycopodium is used industrially for the manufacture of fireworks

Adulteration. Lycopodium is frequently adulterated, the following substances having been found.—potato starch, maize starch slightly roasted and coloured, sulphur, powdered colophony, powdered amber,

dextrin, powdered boxwood, powdered talc, calcium carbonate, and pollen of various kinds, especially that of coniferous trees, which has been actually sold (in Austria) under the name of *Lycopodium hungaricum*, see Fig. 6.

Storage. Lycopodium should be stored in a dry place as it is readily attacked by mould if allowed to become damp.

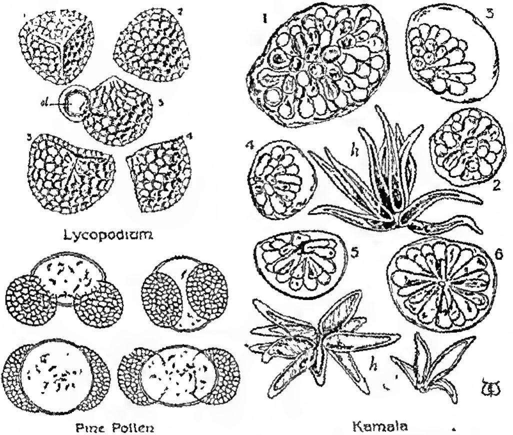

FIG 6. Lycopodium spores. 1, 2, 3, and 4, different aspects of the spores; 5, ruptured spore showing exuded droplets of oil; all × 600 Pine pollen × 300; each pollen grain has two bladdery extensions of the wall, the four drawings show different aspects of the pollen grains. Kamala × 300; 1, 2, 3, 4, 5 and 6, glands of different sizes and different aspects; *h*, groups of trichomes forming stellate structures.

KAMALA. Glandulæ Rottleræ

Sources and History. Kamala consists of the glands and hairs that cover the fruits of *Mallotus philippinensis* Muller Argoviensis family Euphorbiaceæ, a small tree widely distributed throughout India, Ceylon, the Malay Archipelago, Australia, etc.

The drug, which has probably been used in India for many centuries as a dye-stuff, was known to the Arabian physicians of the tenth century, and at the present time still retains in the Indian bazaars its Arabic name, *wars*. It was introduced into European medicine as a vermifuge about 1859.

Collection. The tree produces three-celled capsular fruits about the size of a large pea, and more or less completely covered with a red powder. These fruits are gathered, dried, and thrown into a basket, where they

are shaken and rubbed with the hands; the red powder covering them is detached, and, falling through the basket, is caught on a cloth placed beneath it. This powder, which consists of the glands and stellate hairs from the surface of the fruits, constitutes the drug; it is collected chiefly in Orissa (south-west of Calcutta), Bengal, and Bombay, about the month of March.

Description. *Kamala is a fine, granular, mobile* powder of a dull red or madder colour, without odour and almost tasteless, floating when thrown on to the surface of water. Alcohol, ether, chloroform, and caustic alkalies are coloured deep red by it, but water has little *action on it.* That it is not a homogeneous powder can easily be seen by gently shaking it, when a greyish portion (hairs) will segregate on the surface.

Microscopy. Kamala consists of glands and hairs. The former are of a depressed globular shape and are filled with a deep red resin, secreted by a number of club-shaped cells radiating from a common centre; they are about 40 to 100 microns in diameter. The hairs are thick-walled, curved, unicellular and arranged in small groups; the walls are lignified. See Fig. 6.

Constituents. The most important constituen[illegible]
(from *Rottlera*, a former [illegible]
$C_{27}H_{22}O_7$, which crystalli[illegible] treatment
with hot caustic alkalies [illegible]phloroglucin; by reduction with caustic soda and zinc dust dimethylphloroglucin is produced. The same substances may be obtained from kosotoxin and also from filmarone by similar means, thus showing a remarkable analogy between these three vermifuge substances, all of them being derivatives of phloroglucin. The drug also contains a yellow, crystalline substance, a red and a yellow resin, and wax. Isorottlerin (Perkin) appears to be impure rottlerin. Alcohol extracts about 80 per cent. of resin, which contains about 10 to 12 per cent. of rottlerin.

If quite pure, kamala yields about 1·5 per cent. of ash, but this amount is usually exceeded by the commercial drug, even when of good quality, from which from 3 to 5 or even 10 per cent. may be obtained.

Adulteration, etc. Kamala is often grossly adulterated with ferric oxide or with a ferruginous sand, or with brick dust, inferior qualities of the drug yielding 50 per cent. or even more ash. Its quality may be roughly judged by throwing a *little on* to the surface of water, kamala will float, but most adulterants will sink. Substitutes for kamala consisting of ground safflower (florets of *Carthamus tinctorius* Linn.), dyed starch, etc., have been observed; *they are easily* detected by the microscope.

Uses. Kamala is an efficacious remedy for tapeworm, expelling the worm and producing free purgation.

Related Substance. *True wars or wurus*, a drug analogous to kamala, is obtained in southern Arabia and Africa from the fruits of *Flemingia congesta* Roxburgh, family Leguminosæ. The drug has a dull purplish colour, and is seen under the microscope to consist of glands composed of several tiers of elongated cells (*not radiating from a common centre*), mixed with which are single (not grouped) hairs, it is therefore easily distinguished from kamala. It contains flemingin, which is analogous to, but not identical with, rottlerin, red and orange-brown resins and homoflemingin are also present in it

LUPULIN

Sources. Lupulin consists of the glands obtained [illegible]
Humulus Lupulus Linn. [illegible]
The cone-like, collec[illegible]

of leafy stipules and bracts, the latter enfolding at their base minute fruits. The bases of the bracts, the perigones surrounding the fruits and to a less degree the stipules are sprinkled over with bright shining glands which, when fresh, have a pale greenish-yellow colour, which darkens as the hops are kept. These glands can be separated more or less completely by shaking and beating the ripe hops, and shaking in sieves when about 8 to 12 per cent. of lupulin is obtained from the dry hops. The glands are also detached during the manipulations to which hops are subjected in gathering and drying, and collect together with sand, débris, and other

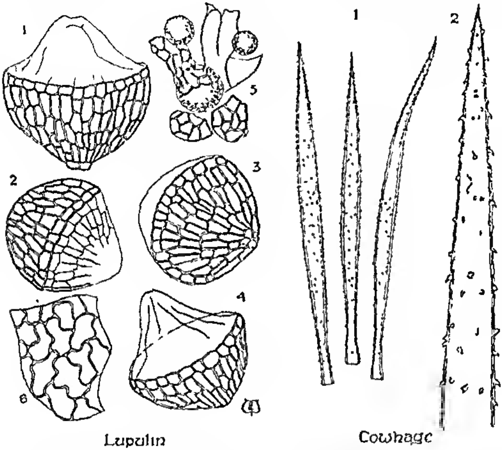

Fig. 7. Lupulin—glands of strobiles of *Humulus lupulus* × 150. 1 to 4, various aspects of the glands; 5, ruptured gland, showing droplets of released oil; 6, fragment of the epidermis of a bract. Cowhage. Trichomes of the fruit of *Mucuna pruriens*. 1, entire trichomes × 50; 2, tip of trichome × 300.

extraneous matter, on the floors of the hop-kilns. By sweeping the floors

secretion of oil or
pressure, which is
oily liquid. The d
Fig. 7.

Constituents. Lupulin contains volatile oil, bitter principles, resin, wax,

and traces of choline, etc. Pure lupulin yields to ether about 80 per cent. of its weight, and leaves on incineration about 2·5 per cent. of ash. Commercial lupulin, however, often gives from 10 to 25 per cent. or even more ash, and yields from 40 to 70 per cent. to ether. By keeping, lupulin gradually darkens in colour and acquires an unpleasant odour.

Adulterants. Lupulin is generally very impure and contains sand, débris of strobiles and other matters from the hop-floors.

Uses. Lupulin is occasionally employed as a stomachic tonic, and also as an hypnotic to promote sleep.

COWHAGE. Mucuna

Sources. Cowhage consists of the epidermal trichomes of the fruit of *Mucuna pruriens* de Candolle, family Leguminosæ, a climbing plant indigenous to India, Africa, and South America.

The fruit, a small, curved, nearly black legume, is densely covered with stiff, yellowish-brown trichomes which form the commercial drug.

Description. Cowhage appears in commerce as a yellowish-brown, loosely felted mass of hairs with occasional small portions of the black pericarp.

Microscopy. The trichomes are nearly straight or slightly curved and unicellular; they are slightly contracted towards the base, somewhat enlarged towards the middle and sharply pointed at the apex. The surface carries numerous small cuticular points, many of which are directed towards the base of the trichome. They are from 1 to 3 mm. long, about 60 microns wide at the base and 100 microns wide at the middle. The walls are moderately thickened and lignified.

Constituents. The hairs contain a little tannin, but their action as a vermifuge is purely mechanical

Uses. Cowhage is used as a remedy against round-worm (*Ascaris lumbricoides*) and thread-worm (*Ascaris vermicularis*) and is administered as an electuary, which is followed by a purgative such as jalap or senna. It is useless for tape-worm.

ARAROBA. Goa Powder

Source, etc. Araroba, or Goa powder, is a powdery material found in cavities in the trunk of *Andira Ararôba* Aguiar, family Leguminosæ, a large tree common in the damp forests of Bahia (Brazil).

Collection. Araroba is collected by felling the tree, sawing the trunk into lengths, and splitting these longitudinally The yellowish powder is then scraped out with the axe, numerous splinters of wood and other débris being simultaneously removed. It is exported in that crude condition, and may be purified by sifting it as free as possible from fragments of wood, drying, and powdering it.

Araroba arises in the wood of the tree-trunk by an obscure change in the walls of all the cells of the tissue, resulting in their complete disintegration and replacement by a yellowish powder. The drug appears to have been long known to the natives of Brazil as a cure for certain skin diseases In 1884 Kemp drew attention to the Goa powder that was used in India for similar purposes, and this was proved in 1875 to be identical with the araroba of the Brazilians.

Description. The crude drug consists of a brownish-yellow or umber-brown powder mixed with numerous small and large fragments of wood The powder consists of numerous minute crystals mixed with granular, amorphous matter and vegetable débris. The smoothed transverse surfaces of the larger fragments of wood show thin, yellow, medullary rays, vessels, and here and there yellow masses (of araroba). Commercial

chrysarobin is made by grinding the crude drug, drying it, boiling it with benzene, filtering, evaporating to dryness and powdering the residue. This is a yellow, micro-crystalline, tasteless, and inodorous powder, soluble in hot chloroform and benzene, almost entirely soluble in hot alcohol, very sparingly and incompletely soluble in petroleum spirit, and practically insoluble in water. Hot solution of potash dissolves it almost entirely. To solution of ammonia it imparts at first a slight pink tinge; this colour quickly deepens owing to oxidation of the chrysarobin, which is insoluble in ammonia, to chrysophanol, which is soluble. Chrysarobin melts when heated, gives off yellow fumes, and finally burns, leaving not more than 1 per cent. of ash.

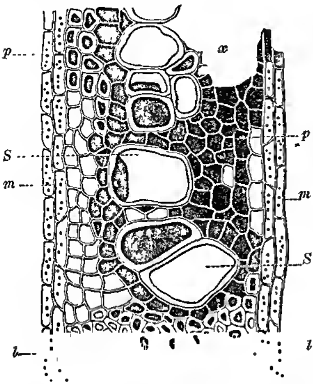

FIG 8. Araroba. Portion of a transverse section of the wood of *Andira Araróba*, near to a cavity filled with araroba. *S*, vessels; *l*, wood fibres; *p*, wood parenchyma; *m*, medullary rays. Nearly all the elements contain a dark substance, which in the upper part forms a dense mass, *x* (omitted from the illustration). Magnified. (Vogl)

Crude araroba, as imported, often contains from 15 to 30 per cent. of water, which appears to be added to prevent the irritating dust from rising; it may yield from 50 to 75 per cent. of chrysarobin.

Constituents. Commercial chrysarobin varies considerably both in the constituents present and the proportions in which they occur. The following table may suffice to indicate its approximate composition (Tutin and Clewer, 1913):—

Chrysophanol (chrysophanic acid) . .	4·7 to 6·7 per cent.
Emodin monomethyl ether . .about	1·6 to 2·2 ,,
Chrysophanolanthranol ("chrysarobin") about	26 0 to 62 0 ,,
Anthranol of emodin monomethyl ether .	small amount
Monomethyl ether of dehydroemodinanthranol	13 4 to 41·1 per cent.
Ararobinol	about 4 ,,
Emodin	trace
Inseparable mixture of substances and amorphous matter . . .about	12 0 to 30·0 per cent.

Chrysophanolanthranol, $C_{15}H_{12}O_3$, crystallises in yellow leaflets melting at 199°. It is insoluble in aqueous ammonia, but is converted by oxidation into chrysophanol which is soluble.

Uses. Purified araroba is been employed for the treatment t acts apparently by destroying fun

CHAPTER IV

FOSSIL ORGANISMS, SHELLS AND MINERALS

DIATOMITE. Diatomaceous Earth. Kieselguhr

Sources. *Diatomite consists almost entirely of the siliceous skeletons* of fossil diatoms, family Bacillariaceæ (formerly Diatomaceæ), a subdivision of the Algæ. Abundant deposits occur in many parts of the world, notably in California and Virginia, in the United States of America, Algeria, Denmark, Germany, Kenya Colony and also in less amount in Scotland (Skye and Aberdeen) and in Northern Ireland. These deposits have been formed in geological time by the rapid growth of diatoms, which have died, and their siliceous contents have fallen to the bottom of the sea or inland lake and have accumulated in vast quantities. Some deposits have been formed in sea-water and others in fresh water.

Collection and Preparation. The deposit is usually mined in open quarries, and large blocks, containing from 25 to 40 per cent. of *moisture, are arranged in stacks to become air-dry, with a moisture* content of 5 to 6 per cent. The blocks are next crushed in mills and the powder is graded by special machinery, usually by air-separators

diluted hydrochloric acid, thoroughly washed and dried

Description. Diatomite is a light brownish grey powder or, after treatment with acid, a white powder, smooth, but not slippery, *adherent to the skin when rubbed, tasteless and odourless. It is* highly absorbent and is unaffected by incineration. Owing to the large volume of air enclosed by the material, the apparent density varies from 0·11 to 0·32, the actual density of silica being about 2 3

Microscopy. A diatom skeleton is formed of two parts, each of which consists of a flat or slightly waved siliceous plate which is sculptured so as to present a pattern of very beautiful design This flat plate varies much in shape and may be oblong, oval, circular, triangular, sigmoid or of some more complex shape, it is named the *valve*. The margin of the valve is *slightly bent over and to it is* attached, at right angles to the valve surface, a band, which gives the entire structure the form of a box lid. The two portions of the skeleton fit together like the lid and bottom of a pill-box, so that one valve is always slightly smaller than its fellow, the two overlapping bands form together the *girdle* of the diatom. The appearance of a diatom is therefore quite different according to its position when under observation; the valve-view shows the surface of the valve plates and the girdle-view shows the diatom from the side. There are two main groups of diatoms, named the *Pennatæ* or *pennate forms, which are* elongated, and the *Centricæ* or discoid forms which are usually circular or triangular. Fresh-water diatoms are more robust in structure than sea-water forms, because fresh water has usually a higher silica content

than sea water. Scattered amongst the diatoms one always finds a few siliceous spicules from sponges. See Fig. 9.

Constituents. Natural diatomite contains from 75 to 92 per cent. of silica together with smaller amounts of aluminium oxide, about 1 to 6 per cent., calcium oxide about 0·2 to 1·5 per cent., magnesium oxide about 0·3 to 1·5 per cent., and often some iron oxide varying from a mere trace to as much as 5·5 per cent. The brownish grey tint is due to the presence of oxide of iron. Diatomite, that has been washed with acid, is almost pure silica.

Uses. The chief pharmaceutical uses are for clarification, filtration and decolorisation and for the manufacture of tooth powders, face powders and nail polishes. The Berkefeld type of filtering "candle" is made of diatomite.

The uses of diatomite depend partly upon its chemical constitution,

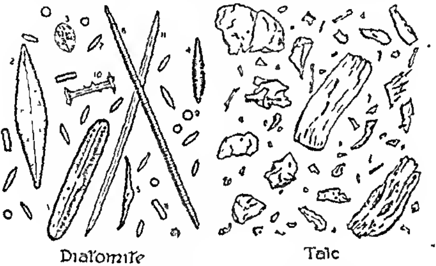

Fig. 9. *Diatomite and Talc, both* × 200.

silica being hard, insoluble and resistant to heat, and partly upon its physic[illegible] form and the sculptured surfac[illegible]

For filtration and clarification select a diatomite containing 50 per cent. or more of pennate forms; for tooth powders use salt-water forms of delicate construction, usually discoid forms, which will be less liable to scratch tooth-enamel than the robust pennate forms. For face powders use a material having a high coefficient of absorption and a delicate construction, usually a discoid form; diatomite does not swell when it absorbs moisture and therefore does not have the harmful effect upon the pores of the skin that results from the use of starch. For nail polishes use angular and robust forms.

PREPARED CHALK. Creta

Sources. Chalk is the substance of which certain ranges of hills are almost entirely composed, examples are the North and South Downs of Southern England. The chalk was deposited when these hills formed part of the ocean floor; the deposit consisted of the shells of

innumerable unicellular animals belonging to the Foraminifera, and the most common genera are *Globigerina* and *Textularia.* There are about twenty-two species of foraminifera in the English chalk.

Collection and Preparation. Chalk is mined in open quarries, ground in a mill, elutriated and the liquid that is run off is allowed to settle. The sediment is formed into flat cakes which are allowed to dry in the air, forming "whiting" For pharmaceutical use, whiting is further purified by elutriation and is afterwards dried in small masses, usually conical in form.

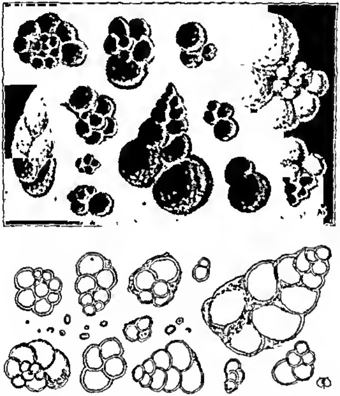

FIG. 10. Prepared chalk Foraminiferous shells, seen in the upper drawing by dark ground illumination and in the lower drawing by transmitted light. The small discs in the lower drawing are the morpholites. All × 200.

Description. Chalk is white, soft to the touch, earthy, amorphous, tasteless and odourless; it absorbs water, but is insoluble in water, it effervesces with acids, including acetic acid

Microscopy. Powdered prepared chalk consists of a large amount of débris of foraminifera amongst
of perfect shells, mostly sp
Globigerina consists of a ser
diminishing in size and arranged spirally, the diameter of an entire shell is about 35 to 80 microns. *Textularia* consists of two series of gradually diminishing chambers arranged side by side to form flattened

conical shells, which are about 50 to 180 microns long and 40 to 100 microns across the base. In addition to the shells and their débris there are always present some very small rings and discs which are usually described as morpholites and the nature of which is obscure; they may be shells of very minute protozoans or they may be due to incipient crystallisation of chalk which has gone into solution in the presence of carbon dioxide. See Fig. 10.

Constituents. Native chalk contains about 98 per cent. of calcium carbonate, 0·5 per cent. of magnesium carbonate, 0·5 to 1·0 per cent. of silica and traces of oxides of aluminium, iron and manganese and of sulphates, phosphates and organic matter. Prepared chalk for pharmaceutical use should contain in the dried substance not more than 0·2 per cent. of silica and oxides of iron and aluminium.

Uses. Prepared chalk is used as an antacid and in the treatment of diarrhœa, also as a dusting powder and in the preparation of face and tooth powders.

Note. Precipitated chalk is easily distinguished microscopically from prepared chalk. Several varieties, differing in physical structure, are known commercially as "extra light," "light," "medium," "heavy," etc. The heavier kinds consist of crystalline or aggregated particles about 10 to 25µ in diameter; these are particularly suitable for dentifrices. The "light" and "very light" kinds consist of a fine powder composed of minute amorphous particles often loosely adherent to form clumps.

CUTTLE-FISH BONE. Cuttle-fish Shell, Sea-biscuit, Os Sepiæ

Sources. Cuttle-fish bone is the internal shell of the cuttle, *Sepia officinalis* Linn., order Dibranchiata, family Sepiadæ, a large mollusc common round the coast of Great Britain and abundant in the Mediterranean and Adriatic Seas, and in the Indian Ocean.

Collection. The animal consists of a flattened, ovoid body with two lateral extensions or fins. It is truncated anteriorly where the narrower head is attached, having the mouth at the centre. Ten long tentacles surround the mouth, which is provided with two large, powerful, horny beaks. The shell is contained in the muscular mantle, beneath the skin of the dorsal surface When the animals die, the bodies decay and the shells are liberated, being eventually thrown up by the sea, and are collected from the seashore.

Description. The cuttle shells are oblong-ovoid and lenticular, about 10 to 25 cm. long, 4 to 8 cm. wide and 1·5 to 3 cm. in maximum thickness. They are biconvex or sometimes plano-convex, the greater convexity being on the outside. The outermost layer is calcareous and white, about 0·1 mm. thick and bears rounded tuberculations a c rugæ about 1 mm. wide and about 0·5 mm. apart. Beneath this is a yellowish chitinous layer about 0·2 to 0·4 mm. thick and within that a thin calcareous layer about 0·1 mm. thick. The remainder of the shell is formed of friable, white, calcareous layers of which there are about 45 to 100 in the thickest part, this inner part is easily crushed by moderate pressure and retains the form of the indentation. The three outer layers project as a thin margin about 3 mm. wide, becoming wing-like below where the inner layers taper off rapidly to a hard rounded point or mucro The shell is practically inodorous and the taste is earthy and slightly saline.

Microscopy. The outer calcareous layer is compact and crystalline; the chitinous layer stains deep yellow with trinitrophenol (picric acid). The remaining 50 to 100 parallel calcareous layers are about 7µ thick and

are separated by spaces about 300 to 375 to 405μ wide. Between the layers, and at right angles to them, are numerous short wavy membranes about 1μ thick, which give the appearance in a transverse section of the shell, of numerous pillars separated by intervals of about 100μ. These [illegible]

thin calcareous plates showing numerous short wavy surface markings where the supporting membranes were attached, and *(c)* sharply angular pieces of the chitinised layer, which are structureless, stoutly built and stain yellow with trinitrophenol (picric acid). When the powder is treated with hydrochloric acid, it dissolves with the exception of the chitinous fragments.

Constituents. Cuttle bone contains about 83 per cent. of calcium carbonate, about 6 to 7 per cent. of chitinous material and small amounts of sodium chloride, calcium phosphate and salts of magnesium.

Uses. Powdered cuttle bone is used in tooth powders, when it is sometimes termed "white coral powder." It is often given to cage-birds who obtain a supply of calcium salts by pecking the friable inner part of the shell. The powder has also been given internally as an antacid and for sprue and dysentery.

TALC. French Chalk. Craie de Briançon

Sources. Talc is a fine variety of steatite or soapstone, which occurs as a massive mineral with a foliated structure, enabling one to split it into thin pieces, which are flexible, but not elastic—the latter character distinguishing it from mica. The mineral is white, or in the less pure varieties with a greyish or greenish tint, and possesses a pearly lustre; it comes chiefly from Piedmont in Italy, from France and New York State.

Description. The powdered mineral is usually purified for pharmaceutical use by boiling with diluted hydrochloric acid, washing with water and drying at 110° C. The resulting material is a fine white, tasteless and odourless powder. When rubbed on the skin it has a feeling of greasiness, usually referred to as "slip." It is insoluble in water, and in acids and alkalies. It has a density of 2·2 to 2·8.

Microscopy. Powdered talc consists of minute particles of various sizes and shapes. The particles are irregular, sharply angular and often show jagged and laminated ends; they are colourless. Between crossed nicols, the particles of powder polarise brightly and often show bright colours. See Fig. 9.

Constituents. Chemically *talc is a hydrated magnesium silicate*, having the formula [illegible], or, as it is sometimes written, $H_2O.3MgO.4SiO_2$. [illegible] per cent. of iron oxide [illegible] or greenish tint of some [illegible]

Uses. Talc is used for the clarification and filtration of cloudy fluids; for the preparation of dusting powders; for coating and dusting pills; as a lubricant for massaging and in the making of tablets.

ASBESTOS

Sources. Asbestos is a fibrous variety of hornblende and occurs in many parts of the world, such as Italy, Canada, Australia and Rhodesia.

It is mined in open quarries and comes chiefly from Canada and Rhodesia

Description. Asbe [illegible] eenish mineral which can be broken easily [illegible] These fibres can be spun and woven to f [illegible] It is unaffected by heat, acids and alkalies.

Microscopy. When some of the fibres are mounted in cresol and examined microscopically, they appear as long, delicate, transparent fibres which are highly refractive and polarise brightly on a dark field when examined with crossed nicols.

Constituents. Asbestos is a double silicate of calcium and magnesium with a varying amount of iron, the formula usually given being $CaMg_3(SiO_3)_4$ or $Ca(Mg,Fe)_3(SiO_3)_4$. It is to the iron that any greenish tint is due.

Uses. Asbestos is used as a filtering medium for caustic alkalies and for making bacterial filters, also as an insulating material for ovens and for packing round boilers and steam pipes and for making fireproof clothing.

KAOLIN. China Clay, Kaolinite

Sources. Kaolin is a pure variety of clay produced by the weathering and decomposition of the felspar of granite. It comes chiefly from the granite districts of Cornwall and Devonshire, where it is mined in open quarries. As mined, it is mixed with varying amounts of quartz, mica and undecomposed felspar and it is purified by elutriating with water, allowing the turbid fluid to settle in tanks and collecting the deposit.

Description. Kaolin is a very fine, soft clay, crumbling to powder when pressed between the fingers and having a slightly soapy feel. It is white or white with a faint yellowish tint; it has a density of 2·3 and is insoluble in water. Dilute acids and alkalies do not affect kaolin, but strong hydrochloric acid decomposes it partially and prolonged heating with strong sulphuric acid converts it into insoluble silica and sulphate of aluminium. When dry it is odourless, but develops a clay-like odour when moistened; it has a slight earthy taste

By subjecting crude kaolin to the process of elutriation, various grades are produced, differing in the size of the particles present. The variety containing the smallest particles is largely colloidal in nature and is the type used for internal administration. A coarser variety containing no colloidal matter is used for assisting filtration and for making preparations such as kaolin poultice.

The two varieties can be distinguished by their behaviour towards water. The *colloidal* type, when kneaded with a small amount of water, forms a stiff, sticky mass, and when suspended in water a permanently turbid fluid results and only a part of the kaolin is eventually deposited. The *coarser* kaolin when similarly treated with water yields a plastic but less sticky mass, and when suspended in water the whole of this coarser kaolin eventually settles, leaving a clear supernatant liquid.

Microscopy. *Colloidal* kaolin consists of very fine particles of various shapes and sizes, many of which are extremely small, often less than

2 microns in diameter; the larger particles polarise brightly and rarely exceed 20 microns in diameter. The smallest particles exhibit the brownian movement when suspended in water. The *coarser* kaolin consists of fine particles, none of which exhibit brownian movement; they are usually flat and irregularly angular.

Constituents. Kaolin is almost pure aluminium silicate and may be represented by the formula $Al_2O_3.2SiO_2.2H_2O$. Very small traces of magnesium, calcium and iron are present and the iron produces the slight yellowish tint seen in some samples. An analysis of a sample of china clay gave the following percentage composition. SiO_2, 46·31; Al_2O_3, 39·91; MgO, 0·44; CaO, 0·43; FeO, 0·27; water, 12·67.

Uses. Kaolin is used in the treatment of certain gastric and intestinal affections. It is also used in filtration as a clearing agent; for making poultices and as a pill excipient.

Note. Colloidal kaolins consist to the extent of 75 to 90 per cent. of particles having a diameter less than 3μ, *i.e.*, true clay. (Partridge, 1913.) Such kaolin is also described as *light kaolin*.

CHAPTER V

HAIRS AND FIBRES

COTTON. Cotton Wool, Absorbent Cotton

Sources and History. Cotton consists of the hairs or epidermal trichomes of the seeds of *Gossypium barbadense* Linn. and other species of *Gossypium*, family Malvaceæ. Cotton has been produced in India since very early times, the plant cultivated being *G. herbaceum*, which is a native of the East Indies, and cotton cloth was first brought to Britain from Calicut in India, whence the name calico for cotton fabrics From India the cultivation spread to China and Egypt, where cotton was cultivated as long ago as 500 B.C. The Phœnicians and Carthaginians introduced the cultivation to the Mediterranean basin, and in 1774 the same plant was taken to the United States of America where it is still often preferred for cultivation. *G. barbadense* is indigenous to the West Indies and yields Sea Island Cotton, which is highly prized because of its long staple, *i.e.*, the great length of the trichomes, and the uniformity of length. *G. hirsutum* is indigenous to North America and yields Upland Cotton. *G. peruvianum* occurs in all parts of South America and was cultivated in Peru probably before the cultivation of cotton in Egypt. The largest amount of cotton now comes from the United States of America, and India and Egypt come next in order as countries of production.

Cultivation, Collection and Preparation. Cotton plants are herbaceous or woody according to the species and the same species may vary with the climate In warm climates the plant is perennial, but it is always grown as an annual because its susceptibility to attack by insects and disease makes it impossible to continue cultivation of the same plants from season to season. The crop is a very exhausting one for the soil and it prefers sands and loams, hence the rich alluvial deposits in the valleys of large rivers, such as the Nile, Ganges, Indus and Mississippi are particularly suitable. The seed is sown in rows 3 to 5 ft. apart, the seedlings are thinned out to from 1 to 2 ft. apart and the surface soil requires constant working between the plants. Nitrogenous manures are applied during the early stages of growth and later on phosphatic manures to cause early and uniform ripening of the capsules or "bolls."

The bolls are ripe about fifty to sixty days after the flower has fallen and they dehisce by three to five valves, exposing the seeds which are contained in a similar number of loculi; each boll contains about thirty-six seeds. The "cotton," as the seeds with the trichomes attached are termed technically, is picked by hand at a time when there is neither rain nor dew and is carefully dried in the shade on hurdles until the seeds can be cracked between the teeth. The seeds are then transferred to a "gin," which is a machine for separating the trichomes, or "lint," from the seeds. In this machine the seeds are fed by a hopper on to a cylinder formed of a set of finely toothed circular saws placed side by side, these drag the hairs from the seeds and the hairs are removed from the saws by a cylinder of rotating brushes and are drawn up an inclined collecting shaft to pass between two rollers which compress them into a felt. This felted "lint" is made into bales by hydraulic pressure.

Cotton for Surgical Use. Absorbent cotton wool is made from cotton waste, *i.e.*, hairs which are rejected by certain machinery during the preparation of cotton for spinning, usually it is the "comber waste" of American and Egyptian cottons. Impurities are first removed and the cotton hair is then boiled with a 5 per cent. solution of caustic soda for about fifteen hours at a pressure of from one to three atmospheres. After thorough washing with water it is bleached by immersion for ten to eighteen hours in a 5 per cent. solution of chlorinated lime, washing with water and transferring to very dilute hydrochloric acid for about four hours. It is next washed with water, treated for about twenty minutes with very dilute hydrochloric acid, washed again, dried, loosened by

r further

"wool."

matter

composed of wax with stearic and palmitic acids.

Description. Absorbent cotton wool is a loosely felted mass of delicate filaments, soft to the touch and white in colour. Raw cotton has a slight brownish tint, a colour which is due to the dried remains of protoplasm and cell contents, the wall of the trichomes being quite transparent and colourless. Absorbent cotton rapidly sinks when placed on the surface of water, but raw cotton is non-absorbent and floats on water, the non-absorbency being due to the presence of the fatty substances in the cuticle.

When a wad of cotton

the fibres holding togeth

before the wad finally

compare with cellulose wadding.

The walls of absorbent cotton being composed of cellulose, cotton responds to the chemical tests for that substance, viz., it is insoluble in 5 per cent. aqueous caustic alkali, it swells evenly in cuoxam (ammoniacal solution of copper oxide) and finally dissolves; it swells and finally dissolves in cold 66 per cent. v/v sulphuric acid; chlorzinc-

reorientation of the molecules of fatty acid which exist in the very small amount of cuticular substance not removed by the treatment with alkali (Savage, 1934).

Microscopy. Cotton consists of trichomes which are tubular and flattened and show numerous twists,

or may change direction in the san

flattened trichome are rounded and

as a distinct margin occupying about one-sixth of the diameter on each side. The wall consists of cellulose and the layer lining the lumen has a firmer consistence than the remainder and often shows, when

The apex is rounded

occasionally it is solid

to 40 microns and the

length from 20 to 40 mm.; in absorbent cotton wool the "staple," as the length of the trichomes is termed technically, should not be less

than 16 mm. as an average. The standard staple is comparatively short because absorbent cotton is made from "waste," which consists mainly of short fragments of trichomes. See Fig. 11.

Raw cotton can be distinguished microscopically from absorbent cotton by its behaviour towards cuoxam, which causes raw cotton to swell at intervals into spherical expansions separated by constricted

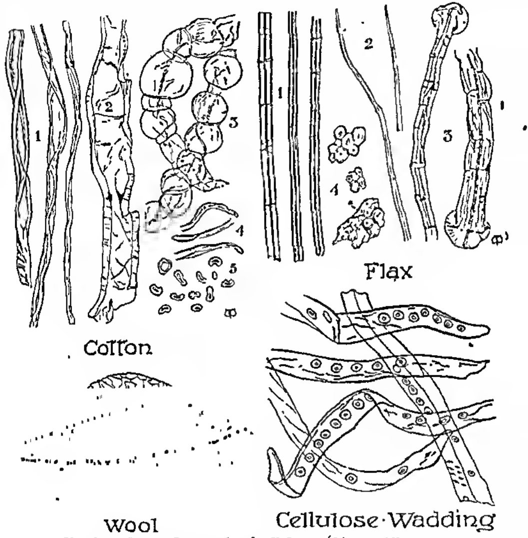

Fig. 11. Cotton, flax, wool and cellulose wadding All × 130.
Cotton. 1. Mounted in glycerin. 2. Absorbent cotton in cuoxam. 3. Raw cotton in cuoxam. 4. Apices of trichomes. 5. T.SS. of hairs.
Flax. 1. Isolated fibres. 2. Apices of fibres. 3. Swelling in cuoxam. 4. T.SS. of fibres, *a* adhering parenchyma

regions, the constrictions being caused by the cuticle, which shrinks back from the expanded portions to form a tight intervening band.

The trichomes, as they exist in the capsules before dehiscence, are quite cylindrical and exhibit no twists, the flatness and twists arise during drying in the air and sun. The twists are due to the variation in density of the different parts of the wall, especially to the presence of the denser part lining the lumen and to the strains produced by the

cellulose given under cotton wool and gives no reaction for lignin when tested with phloroglucin and hydrochloric acid. It is very absorbent and sinks in water rather more rapidly than cotton wool.

Microscopy. The fibres of wood cellulose show the structure of the elements of the wood from which it has been made. In the great majority of samples the elements present are tracheids of some tree belonging to the Pinaceæ, often a species of *Pinus* itself. Usually the markings present are the large bordered pits characteristic of *Pinus*. The pits and the outlines of the cells appear somewhat faint and less clearly marked than in the corresponding wood, this being due to the drastic treatment to which the wood has been submitted. When the action of cuoxam on wool cellulose is observed microscopically, some

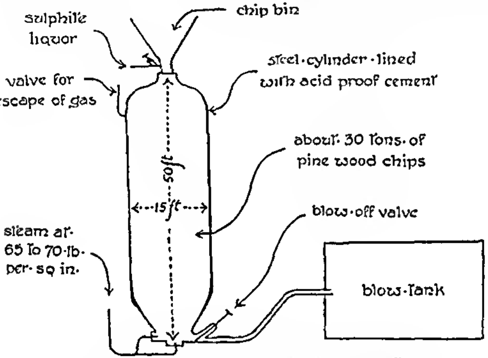

FIG. 12. Diagram of plant for manufacture of wood cellulose. (From "Industrial Chemistry," by Read; modified.)

fibres show spherical swellings closely resembling those of raw cotton, but if other parts of the same fibre are examined, bordered pits will be found, thus distinguishing them from cotton. See Fig. 11.

Constituents. Wood cellulose consists almost entirely of pure cellulose.

Uses. Wood cellulose is used for many of the purposes for which absorbent cotton wool is used and in certain cases it is to be preferred because of its high absorbency and the readiness with which it disintegrates.

FLAX

Sources. Flax consists of the strands of pericyclic fibres removed from the stem of the flax or linseed plant, *Linum usitatissimum* Linn., family Linaceæ. The manufacture is carried on chiefly in Russia, Northern Ireland, United States of America and Argentina.

Uses. Flax was formerly used in the manufacture of lint, but lint is now made entirely from cotton. Linen cloth is used as a filtering medium for some preparations.

HEMP, like flax, consists of pericyclic fibres and is obtained from an annual plant, *Cannabis sativa* Linn., family Cannabinaceæ. The fibres are separated by processes very similar to those used for flax, the manufacture being carried on chiefly in Russia, Italy and France.

Hemp fibres give reactions for cellulose, modified by the presence of a

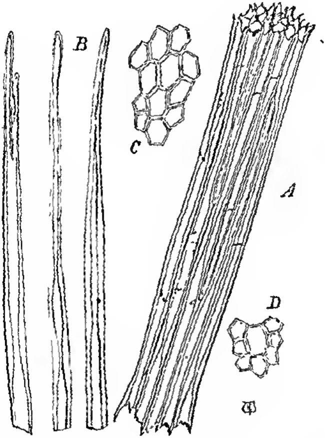

Fig. 13. Jute. Phloem fibres of *Corchorus sp.* *A*, portion of a strand of fibres. *B*, apices of isolated fibres. *C* and *D*, transverse sections of strands of jute. All × 300.

small amount of ligno-cellulose and they show transverse lines and striations similar to those of flax. Hemp can be distinguished by the appearance of transverse sections where the cavities of the cells appear relatively large and are oval or elongated in shape; the ends of the fibres are blunt and rounded and sometimes spatulate. The coarser varieties of hemp are further distinguished by the presence of incompletely removed

direction. Hemp is used chiefly for the manufacture of rope, twine, sail-cloth, etc.

JUTE. Gunny

Sources. Jute consists of the strands of phloem fibres removed from the stems of *Corchorus olitorius* Linn. and *C. capsularis* Linn., family Tiliaceæ. The plants are annuals, from 5 to 10 ft. high and very little branched; they are cultivated chiefly in Bengal. When they are partly in fruit, the stems are cut and are retted in stagnant water for ten to twenty-five days. The bark is then stripped off and picked and washed till free from semi-decayed parenchyma The residual strands of phloem fibres are dried and constitute jute.

Description. The strands of jute are from 1 to 3 metres long and 30 to 140 microns in diameter, they are pale buff or silvery grey and somewhat coarse in texture. It has great tensile strength and is hygroscopic, absorbing as much as 25 per cent of moisture.

Microscopy. A transverse section across one of the strands shows it to be formed of a group of cells, polygonal in outline and having a rounded lumen which varies considerably in size The strands respond to the tests for lignified tissues, giving a deep red with phloroglucin and hydrochloric acid and a yellow colour with chlorzinciodine and with N/50 iodine followed by 66 per cent v/v sulphuric acid.

To separate the strands into their individual cells they must be treated with an oxidising agent such as a mixture of potassium chlorate and 50 per cent nitric acid or a mixture of 10 per cent. each of chromic and nitric acids When the individual fibres are examined they are seen to be quite smooth, without longitudinal striations or transverse lines The lumen or cell-cavity is not uniform throughout the length of each fibre, but owing to variations in the thickness of the wall it is contracted at places, sometimes so greatly as to completely obliterate the lumen, this variation explains the corresponding variation of the size of the lumen in the transverse section of a strand of fibres The ends of the fibres are rounded and blunt, sometimes almost spatulate The dimensions of the fibres are about 0·8 mm to 4 or 5 mm in length and 10 to 25 microns in diameter. See Fig. 13.

Constituents. Jute consists chiefly of ligno-cellulose, it contains not more than 13 per cent of moisture and is free from xylem elements, which are technically termed "root" A small amount of cellulosic parenchyma often adheres to the fibres.

Uses. Pharmaceutically jute is used for the manufacture of tow, which is used for making medicated tow, for padding splints, as a filtering or straining medium and for soaking up fluids In the textile industry jute is used chiefly for making sacking and coarse bags

WOOL. Animal Wool, Sheep's Wool

Sources. Wool consists of the hairs from the fleece of the sheep, *Ovis aries* Linn, family Bovidæ, order Ungulata. It is imported chiefly from Australia, United States of America, Argentina and Russia, it is also produced in considerable quantities in the British Isles

Preparation. The hairs, forming the fleece, are removed from the sheep at shearing time and are thoroughly cleansed from dirt and wool-grease by means of soap and alkali, the wool is finally bleached The wool-grease, after careful purification, forms the valuable wax known as wool-fat or lanolin.

Description. Wool occurs as a loosely felted mass of elastic, lustrous, more or less curly hairs, smooth and somewhat slippery to the touch. A wad of wool resists tearing with considerable force, owing to the tendency of the hairs to cling together. Wool is readily soluble in 5 per cent. aqueous caustic alkali, but is unaffected by dilute acids or by cold strong sulphuric acid. Strong hydrochloric acid, either hot or cold, is without action on wool, but will readily dissolve silk. Cuoxam does not dissolve wool or cause it to swell, but colours the wool blue. Solution of iodine stains wool yellow.

Microscopy. Wool consists of more or less curved, sub-cylindrical threads, covered with irregular lines crossing them transversely at fairly close intervals and connected by other lines more or less at right angles to them. The lines project slightly at the edges of the hairs, all the projecting points being directed toward the apices of the hairs. A darker coloured narrow band is present along the central axis of many of the hairs and is termed the medulla. The width of the hairs is about 15 to 25 to 45 to 60 microns. Wool fibres polarise brightly with crossed nicols, many hairs showing bright colours. See Fig. 11.

Like other animal hairs, wool consists of a solid cylinder composed of three types of closely packed cells composing the cuticle, the cortex and the medulla respectively. The *cuticle* consists of flattened, imbricated epithelial cells or scales; these have no nuclei and their free margins point

flattened by mutual pressure. The cortex exhibits numerous very fine longitudinal striæ, which are the lines of separation between the individual cells. The cortex forms the great bulk of the hair and upon it depend the firmness, elasticity and colour of the hair. The *medulla* consists of polyhedral and rounded cells, containing nuclei and globules of fat. Air is often present in the interstices between these cells and gives rise to the dark appearance often seen in the medulla.

Constituents. Wool consists almost entirely of keratin, a substance which belongs to the proteins and is closely related to the material of which horn, nails and feathers are composed. Keratin contains the elements C, H, O, N and S. The presence of nitrogen is shown by the odour of burnt feathers given off when wool is burnt and by the evolution of ammoniacal vapour when it is heated with dry soda-lime. The protein nature of wool is evidenced by the reaction with picric acid, which colours wool deep yellow and with Millon's reagent which colours wool brick-red on gentle warming. That wool contains sulphur is shown by adding some wool to a boiling mixture of solution of lead acetate and caustic soda, when a blackening results owing to the formation of sulphide of lead.

Uses. Wool is used pharmaceutically as a filtering and straining medium and for the manufacture of such dressings as flannel, domette and crêpe bandages.

SILK

Sources. Silk is a fibre made from the threads unwound from the cocoons spun by the larvæ of certain moths, order Lepidoptera. The

finest silk comes from the larvæ of *Bombyx mori* Linn., family Bombycidæ, which feed on the leaves of the mulberry, *Morus nigra* Linn., family Moraceæ, while a less valued variety is obtained from the larvæ of *Antheræa yama-mai* Guer., family Saturnidæ, which feed on the leaves of a Japanese oak and yield tussah silk. Other species of *Bombyx* and of *Antheræa* also produce silk. The most important countries where silk is cultivated are Japan, China, Italy and France, the finest varieties coming from France and Italy.

The silk thread is a solidified secretion from two large glands found in each larva or caterpillar. The glands correspond to two of the salivary glands of other insects; they extend throughout the greater part of the length of the larva, which is about 8 cm. long, and owing to the voluminous coils of the glandular tube, the total length of each gland is about 35 cm. The diameter of the gland is greatest in the central region and it tapers towards the head of the larva, where it ends in a very fine tube, the two tubes opening into a common spinneret upon the labium (one of the mouth parts) beneath the head. Other two salivary glands of the ordinary type open into the mouth of the larva.

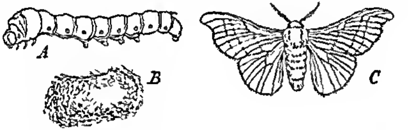

FIG. 14. *Bombyx mori*, the silk-worm moth. *A*, caterpillar, *B*, cocoon *C*, moth (after Westwood).

development. On hatching out, the grubs are about 1·5 mm long, they creep through the gauze and eat the young mulberry leaves placed on the envelopes. They take about four weeks to attain their full size and moult their skins four times; after the last moult they are about 4 cm. long and eat a final meal of about twenty times their own weight of mulberry leaves

loosen the gum which causes the silk threads to adhere; the ends of the threads from two to six cocoons are caught up and wound into a single thread, which is made up into a hank. The eggs being all hatched simultaneously, all the moults and other stages of development occur at definite times and the cocoons are finally spun and are ready for treatment all at the same time; this effects much economy in time and in material, including mulberry leaves. A certain number of cocoons is reserved and the moths are allowed to emerge and mate, after which the females lay 300 to 400 eggs each on separate pieces of gauze. Both the eggs and the parent insect are examined for disease and, if none is present, the eggs are stored in a refrigerator until a new brood of larvæ is wanted. See Fig. 14

Description. Silk threads are very fine, smooth and solid and are usually yellow in colour. Silk is soft and smooth to the touch, possesses considerable tensile strength and elasticity and is hygroscopic. Silk is easily soluble in cuoxam, in cold sulphuric acid 66 per cent. v/v, and in strong hydrochloric acid (s.g. 1·16); in 5 per cent. aqueous caustic alkali silk dissolves only with difficulty, even on boiling; with lead acetate and caustic soda it gives no blackening; all these characters distinguish silk from wool. Towards picric acid, Millon's reagent, iodine solution and heat silk behaves in the same way as wool.

Microscopy. Silk appears as solid, structureless, cylindrical or slightly flattened, highly refractive threads, from 5 to 65 microns in thickness and the solubility reactions mentioned above can be observed under the microscope. Silk threads polarise brightly between crossed nicols and many threads show bright colours.

Constituents. Silk consists chiefly of the protein fibroin, which forms the mass of the fibre; this is coated externally by another protein, sericin or silk-gum, which cements the fibres together and is soluble in warm water, being therefore largely removed when the silk is wound from the cocoons. The proteins of silk contain C, H, O and N, but no sulphur.

Uses. Silk is used pharmaceutically for making ligatures, oiled silk and certain types of sieve.

CHAPTER VI

WOODS

WOODS used pharmaceutically consist almost entirely of the tissue named xylem and the great bulk is secondary xylem formed by the activity of the cambium. At the centre of a log a very small amount of other tissues is present, for example, a log of quassia wood measuring from 10 to 30 cm. in diameter includes the pith which was present in the primary stem and is about 2 or 3 mm in diameter; a very small amount also of primary xylem abuts upon the periphery of the pith.

The **density** of the cell walls of which wood is composed is about 1·5, so that all woods, on becoming waterlogged, *i.e.*, the cell cavities filled with water, will sink in water. Ordinarily woods float on water because air is present in the cell cavities and, in the air-dry condition, they are more or less dense according to the thickness of the cell walls of the constituent cells and to the extent to which resin, oil, tannin or other contents fill the cell cavities. The term density is usually applied to the air-dry wood, containing about 12 per cent of moisture. The densities of the common woods used pharmaceutically are :—

Quassia, *Picræna excelsa*, 0·54 to 0·56
Guaiacum, *Guaiacum officinale* and *G. sanctum*, 1·16 to 1·4.
Logwood, *Hæmatoxylon campechianum*, 0·81 to 1·07.
Sappan, *Cæsalpinia sappan*, 0·96 to 0·98.
Red Sanders, *Pterocarpus santalinus*, 0·75 to 0·82.
Sandal, *Santalum album*, 0·9 to 1·14.

A large proportion of most commercial woods consists of **heart-wood** or **duramen**, by which is understood xylem tissue which has ceased to perform any conducting function and consists of dead cells, the vessels being usually blocked by ingrowths. Xyl… ; of conducting elements and living cell… It frequently happens that … …ing to the deposition of tannins, res… …uring matter in the cells, more especially in the cells of the parenchyma and the medullary rays … woods, like guaiacum and red sand… wood, the paler p… of this paler w… …unction and therefore … …t-wood. Commercially, however, the te… wood is applied usually to the dark coloured wood only.

The **external characters** of a wood are observed on surfaces exposed by cutting the wood in three specified directions at right angles to one another, viz., a transverse surface, a radial surface and a tangential surface, the two latter being longitudinal.

The **transverse surface** is the most useful for providing distinguishing characters. *Annual rings* are evident as bands crossing the piece of wood from one radial surface to the other. Each ring consists of spring wood and summer wood, the latter being much darker in appearance, owing to the smaller lumina of the cells and forming a

dark line on the outer edge of each annual ring. These rings are usually well marked in woods of temperate regions, but are often absent from tropical woods because there is not sufficient seasonal variation to materially affect the size of the xylem elements. Guaiacum and sappan woods show annual rings, but quassia and logwood have none. Crossing the annual rings at right angles are fine parallel lines; these are the *medullary rays*. In guaiacum and Surinam quassia these lines are very fine indeed, because the rays are uniseriate, *i.e.*, only one cell wide. In Jamaica quassia and hæmatoxylon they are somewhat coarser, the rays being multiseriate, *i.e.*, two to several cells wide. The medullary rays usually appear lighter in colour than the remainder of the wood, and the number of rays per unit of arc varies in different woods and frequently supplies a useful diagnostic feature. In the substance of the wood between the rays, small holes or *pores* are evident: these are the vessels of the xylem and terms are used to describe their arrangement. A wood or timber is said to be *diffuse porous* when the vessels or pores, which occur either isolated or in small groups, are scattered uniformly throughout the wood as in quassia, guaiacum and logwood. A wood is described as *ring porous* when the vessels occur chiefly in the earliest formed spring wood and thus form well-marked concentric rings as in oak and ash. Associated with the vessels there are usually small patches or bands of tissue, rather paler in colour than the remainder of the xylem. These patches and bands are the *xylem parenchyma* and it is described as diffuse when scattered more or less evenly throughout the wood. Parenchyma which occurs in tangential bands of varying extent is named metatracheal, that which occurs adjacent to the vessels, but not completely surrounding them is paratracheal and that completely surrounding a vessel is vasicentric. The remainder[1] of the wood consists of *fibres* upon which the strength and hardness of the wood mainly depends. A wood with straight fibres arranged parallel to one another will split easily, leaving smooth longitudinal surfaces, and is called *straight-* [illegible] an *interlocked grain*, *e.g.*, guaiacum wood.

The radial surface shows the vessels as coarse lines running vertically down the surface and the medullary rays appear as narrow horizontal bands crossing the direction of the vessels. On a tangential surface, the vessels appear as on a radial surface, but the medullary rays are now seen as small lenticular areas. In many tropical woods, such as quassia an appearance known as *ripple marks* is evident on this surface and is due to the occurrence of the medullary rays in horizontal rows, all the rays being equal in height, so that the wood is divided into a number of narrow layers or *storeys* and is said to be *storied* in structure.

Histology. Commercial woods are composed of five types of cell-element; these are tracheids, vessels or pores, fibres, cells of the soft tissue

[1] Timber from species of *Pinus* consists almost entirely of one type of element—*tracheids*—which perform two functions, those of conduction and of support.

or parenchyma, and cells of the medullary rays. Tracheids are conducting elements and they form the great bulk of woods of the coniferæ. Each tracheid consists of a single cell with tapering and bluntly pointed ends; the diameter varies widely, some tracheids, like those of *Pinus*, being quite slender, about ten to twenty times as long as they are wide, while others have dimensions similar to those of the segments of large vessels and are described as *vessel-tracheids*. In fact, the only critical difference between a tracheid and a vessel-segment is that the end walls separating tracheids from one another are never perforated, while those of a vessel

membrane is always intact. The pits on the side walls are not necessarily similar in character over the whole surface; where tracheids adjoin other tracheids, the pits are bordered and where they are in contact with cells of a medullary

the medullary

the cell-eleme

obliquely and are perforated by numerous small elongated openings leaving ladder-like bars. The side walls of vessels often bear numerous pits, which are usually bordered, but vary in form and distribution in different parts in a manner similar to that found in tracheids. The vessels of the protoxylem are more simply constructed than other vessels and

outline, while pits in successive rows alternate in position. In many

termed *pitted* vessels. The pits are sometimes very much elongated, extending entirely across each of the flat faces of a prismatic vessel-segment, and they are regularly arranged in vertical rows down each face so as to give rise to a ladder-like appearance; such vessels are named

of the vessel and

cavity

it may

become heavily thickened like sclereids. Thylosis is well exhibited in sassafras wood.

Fibres of the xylem are mechanical or supporting elements, and each

consists of a single prosenchymatous c
section and are from thirty to fifty
tapering ends. The cavity is narrow,
and slit-shaped. Typically thick-walled fibres occur in guaiacum, but in quassia the walls are comparatively thin and the lumen large. Fibres sometimes have delicate transverse partitions formed of cellulosic or pectic material and are then called ***septate fibres***; such fibres occur in teak wood and also in the fibrous bundle sheath of ginger. Cell forms, intermediate between tracheids and fibres, occur in ephedra and in calumba root; they have walls thicker than those of the ordinary tracheid, while the pits are larger than those of the typical fibre and the ends are less tapering. These fibro tracheids do not contain protoplasm or starch.

Xylem parenchyma consists chiefly of square-ended cells arising by the segmentation of cambial cells by transverse walls, so that they are arranged in vertical files of about three to five cells, the end cells of each file being somewhat pointed at one end. In the living wood, these cells contain protoplasm, a nucleus and storage material, such as starch; the starch is frequently present in the wood of commerce, such as quassia wood. The walls of xylem parenchyma are usually pitted with simple, circular pits, but the form of pitting may vary according to the type of adjoining element. Crystals of calcium oxalate, usually prisms, occur in the xylem parenchyma especially that adjacent to the fibres, and such cells are usually subdivided into small approximately cubical cells each containing one prism of calcium oxalate. In some plants, such as *Cephaëlis Ipecacuanha* and *Jateorhiza palmata*, the cambial initials are transformed directly into storage cells of the xylem without the formation of transverse divisions; this produces a type of cell intermediate between a fibre and a cell of the xylem parenchyma. These cells are pitted like parenchyma and contain living contents and storage materials, such as starch, and are therefore a kind of modified parenchyma; they are usually known as **substitute fibres** and each one corresponds to a file of normal parenchyma.

Medullary rays. The cells of the medullary rays are parenchymatous with square ends and simple pits; their function is mainly that of storage and they often contain starch grains and sometimes calcium oxalate crystals. If the cells of a medullary ray are all similar, the ray is termed *homogeneous*, but if some of the cells differ morphologically from the remainder, as is the case in *Pinus*, the ray is termed *heterogeneous*.

The middle lamella of woody tissues is the most highly lignified part

unit of which has a benzene nucleus to which are attached a phenolic hydroxyl group, a carboxyl group and an aliphatic side-chain containing aldehydic, carbinol and unsaturated groups. This aromatic aldehydic substance is thought by some to be combined with the cellulose by a glycosidic linkage to give ligno-cellulose, the characteristic substance present in lignified cell walls. Others regard the middle lamella as being almost pure lignin and the thickening as consisting of micellæ of cellulose occupying the interstices of a complex lignin molecule. Lignin is readily decomposed by oxidising reagents such as a mixture of nitric and chromic acids, 10 per cent. of each in water, or nascent chlorine as produced by a mixture of 50 per cent. nitric acid and powdered potassium chlorate (sometimes known as Schulze's maceration fluid); the chromic acid mixture is used at ordinary temperatures, but the chlorine reagent is used at the boiling point. When pieces of wood are treated with either of these reagents, the middle lamellæ are destroyed and the constituent cells of the

the lignin is at which no longer respond to tests

Lignified walls are permeable to water, but do not retain any appreciable amount as do cellulose walls; they are completely soluble in 80 per cent. v/v sulphuric acid and are insoluble in cuoxam. Dilute aqueous iodine (N/50) followed by a dehydrating agent such as zinc chloride or sulphuric acid gives a yellow colour; aniline salts stain them yellow; phloroglucin 1 per cent. in alcohol followed by strong hydrochloric acid colours them red. Lignified walls act as a reducing agent when treated with the greenish-red fluid obtained by mixing ferric chloride and potassium ferricyanide, in which they induce the formation of a blue precipitate.

Classification of Woods

Woods without Vessels

A. Coniferous woods: Deal.

Woods with Vessels

B. Aromatic woods: Sassafras, Sandal.
C. Bitter woods: Quassia, Surinam Quassia.
D Coloured woods: Guaiacum, Red Sanders, Logwood, Sappan

DEAL. Red Deal, White Deal, etc.

Sources. The timber or wood of *Pinus sylvestris* Linn, the Scot's pine, is known as red or yellow deal, and that of *Picea excelsa* Link, the Norway spruce, is known as white deal. Several other species of *Pinus* and of *Abies* yield similar woods, which come from Canada and the United States of America as well as Europe. These trees belong to the family Pinaceæ.

Description. There is much similarity in the coniferous woods and a description will be given of red or yellow deal, from *Pinus sylvestris*, as an example The wood is rather soft and buff in colour, it has a density varying from about 0 35 to 0·8 and its odour is somewhat resinous It has a straight grain and splits readily longitudinally leaving smooth surfaces; the annual rings are well marked and each is bounded externally by a narrow, dark band of autumn wood. Vessels are absent, but resin ducts occur in the central and outer part of each annual ring, but are not more numerous than fifteen per centimetre of arc in any annual ring. The medullary rays, which number about four or five per millimetre of arc, appear as very fine whitish lines and are of two widths, an occasional ray appearing wider than the others Parenchyma is present in very small amount surrounding the resin ducts and only visible with a microscope In a radial surface, numerous medullary rays cross the grain and appear as narrow light-coloured horizontal bands; resin ducts run parallel to the grain in small numbers appearing as brownish vertical streaks, the autumn wood of the annual rings appears as dark vertical lines The tangential surface shows resin ducts as on the radial surface and also very minute inconspicuous paler dashes, which are the medullary rays.

Histology. The wood of *Pinus sylvestris* consists almost entirely of

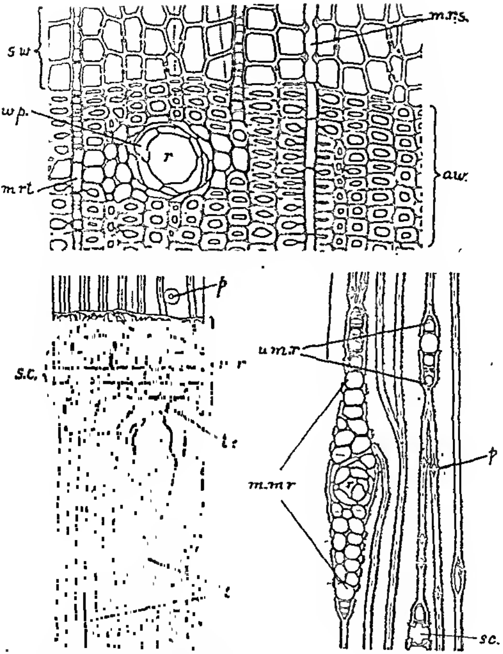

FIG. 15. Wood of *Pinus sylvestri*
through an annual ring. Left-h
section and the right-hand one
after Kny. *aw*, autumn wood,
m.r., medullary ray; *m.r.s.*, starch cells of medullary ray; *m.r.t.*, tracheidal cells of medullary ray; *p.*, bordered pit; *r.*, resin duct; *s.c.*, starch cells; *s w.*, spring wood; *t.*, tracheids; *t c*, tracheidal cell; *u.m.r.*, uniseriate medullary ray; *w.p.*, wood parenchyma. All × about 250.

they form ingrowths, which completely block the older ducts. Associated with each resin duct is a very small amount of thin-walled cellulosic

ray. The rays are heterogeneous; the central two or three rows of cells are somewhat elongated rectangular or rhomboid parenchymatous cells having large simple sub-rectangular pits, one such pit occurring in each area, known as a **cross-field**, outlined by the intersection of a tracheid and a ray cell. These ray cells have from five to eight large pits on each radial wall and in the sap wood they contain starch and are therefore known

with m

walls.

The

method of identifying the woods obtained from closely related coniferous trees. For example, white deal—the wood of *Picea excelsa*—has two or more small bordered pits in the cross-field and the pits occupy only a small part of the total area of the field.

Constituents. The chief constituents are cellulose about 57 per cent. and lignin about 25 per cent; there are also present a small quantity (about 1 per cent.) of resin (colophony) and of volatile oil (turpentine).

Uses. Deal is used as the chief source of wood cellulose and also for making mechanical wood pulp.

SASSAFRAS WOOD

Sources. Sassafras wood is the wood from the root of *Sassafras variifolium* O. Ktze (= *S. officinale* Nees), family Lauraceæ, a small diœcious tree growing in the eastern districts of North America from Canada to Florida and comes chiefly from the eastern states of the United States of America.

Description. The wood occurs in logs up to 20 cm. thick, in branching billets or in chips, it is greyish brown to greyish red-brown in colour and is coarse-grained, soft and easily cut, the annual rings are well marked; the vessels are largest and most numerous in the spring wood, giving a ring-porous appearance, they are smaller and much less conspicuous in the summer wood; the medullary rays are narrow and paler than the remainder of the wood, as seen in the transverse surface, odour fragrant, aromatic and reminiscent of fennel; taste aromatic and sweetish.

Histology. The bulk of the wood consists of fibres which have larger lumina and are somewhat thin-walled in the spring wood, but are thick-walled in the summer wood. The larger vessels of the spring wood are

often half the width of the xylem strand between two medullary rays, in the autumn wood they are fewer and half the diameter or less; many of the vessels are closed by thin-walled thyloses. The medullary rays are one to four cells wide and contain red-brown contents. Oil cells are scattered throughout the wood and occur in the medullary rays and amongst the fibres. The medullary rays, xylem parenchyma and substitute fibres contain abundant rounded starch grains about 6 to 24 microns in diameter.

Constituents. About 2 per cent. of volatile oil, which contains safrol (about 80 per cent.), phellandrene and pinene.

Uses. Sassafras wood is used as a diuretic, stimulant and diaphoretic.

SANDAL WOOD. Yellow Sandal Wood, Lignum Santali

Sources, etc. The yellow sandal wood tree, *Santalum album* Linn, family Santalaceæ, is a small tree distributed over India and the Malay Archipelago. It is found especially in Southern India, from Mysore to Madras, and is regularly cultivated there for the sake of its wood, which has long been used in India in religious ceremonies. It was known in the eleventh century, and has been used medicinally since the middle of the fifteenth century.

The yellow sandal wood tree is a Government monopoly in Mysore, whence nearly all the sandal wood of commerce is obtained. The tree is plentiful, but must be grown slowly in arid situations upon poor and stony soil to yield the largest proportion of oil.

Collection and Preparation. The tree is uprooted and roughly deprived of its bark and part of the sapwood. It is then taken to certain depôts (of which there are nine in Mysore) where the trunks are sawn into lengths of about a metre and trimmed, and the roots are freed from bark. The logs are sent either direct to London, or by native craft to Bombay or other ports on the west coast of India, whence they are exported to London. Periodical auctions of the wood are held in Mysore, where also a certain amount of oil is distilled and exported.

Description. Sandal wood logs are about a metre in length and up to 15 or 20 cm. in diameter, consisting of the heartwood only of the tree. This is yellowish or pale reddish in colour, hard, heavy, and dense, but easily split. The transverse surface shows alternating lighter and darker zones; the medullary rays are very fine and close together; the vessels are mostly solitary, being only occasionally arranged in small radial groups. The taste is slightly bitter, the odour strong and fragrant.

In yellow sandal wood a volatile oil is deposited in the heartwood and is found in all the elements of the wood; it is not secreted by or contained in any particular cells or glands.

Constituents. The imp ... 0·972 to 0·985; o.r. $-13°$ to -2 ... The chief constituent of ... a mixture of α- and β-santalols), of which it contains over 90 per cent.

Uses. The wood is used as a source of the volatile oil, and technically for the mânufacture of boxes, carvings and similar articles. It is also used in perfumery. Sandal wood oil is a stimulant and disinfectant of the whole genito-urinary tract.

VARIETIES. *West Indian Sandal wood, Amyris balsamifera* Linn., family Rutaceæ; vessels in radial groups; sp. gr. of volatile oil 0·900 to 0·967; o.r. $+24°$ to $+29°$; contains 50 per cent. of amyrol.

Australian Sandal wood, Eucarya spicata Sprague and Summerhayes family Santalaceæ; sp. gr. of volatile oil 0·970 to 0·976; o.r. $-3°$ to $-10°$; contains not less than 90 per cent. of free alcohols calculated as $C_{15}H_{24}O$.

South Australian Sandal wood, Santalum Preissianum Miquel (= *Fusanus acuminatus* Robert Brown); sp. gr. of volatile oil 1·022; rose-like odour.

Fiji Sandal wood, Santalum Freycinetianum Gaudich (= *S. Yasi* Seem.); sp. gr. of volatile oil 0·9768; o r. — 25 5°; odour slight.

Several other fragrant woods are known, *e g.*, those of *Osyris tenuifolia*, family Santalaceæ, from East Africa; *Olearia Traversii* F. Mueller, family Compositæ, New Zealand; *Brachyleana Hutchinsii* Hutchinson, family Compositæ, Nairobi

QUASSIA WOOD. Lignum Quassiæ. Quassia

Sources, etc. Jamaica quassia wood is derived from *Picræna excelsa* (Sw.) Lindley, family Simarubaceæ, the lofty bitter-wood tree, which grows to a height of 15 to 30 metres, somewhat resembling in habit an ash or ailanthus, it grows in the West Indian Islands generally and is exported from Jamaica, where it is common on the plains and lower mountains.

Quassia wood was introduced into medicine about the middle of the eighteenth century, but was then obtained from *Quassia amara* Linn., a small tree or bush indigenous to the north of South America, whence its distinctive name of Surinam quassia The wood of *P. excelsa* was found to possess similar properties, and has been substituted for it in England, Surinam quassia, however, is official on the Continent.

Collection and Preparation. The tree is cut down, the smaller branches are removed and the trunk and large branches are sawn into logs and billets, which are 1·5 to 2 metres in length and 20 to 30 cm in diameter. For pharmaceutical use the bark is removed and the wood is cut across the grain by large chisel-like knives and the shavings are kiln-dried to prevent the development of moulds, which grow readily in the fresh wood The wood also occurs in the form of chips and more rarely as small cubes with an edge of about 6 mm

Description. Quassia is yellowish white to yellow in colour and has a specific gravity of 0 54 to 0·56, the grain is straight and the wood splits easily longitudinally, exposing a smooth surface, annual rings are absent, the wood is diffuse porous, the vessels occurring isolated or in small groups of two to eleven The medullary rays appear in a transverse surface as fine straight white lines, about six to eight per millimetre; the xylem parenchyma is chiefly in tangential bands of two kinds, some of which are almost continuous at intervals of about 2 to 4 mm, giving rise to an appearance resembling annual rings and often referred to as "false" annual rings, the other kind of band is from 0·5 to 4 mm. long and is very numerous, being arranged in about six to twelve irregular rows between any two of the nearly continuous bands, the bands of parenchyma are almost invariably associated with the vessels, the darker intervening areas consist of fibres. Some specimens of the wood show dark greyish patches, which are due to the presence of the hyphæ of a fungus infecting the wood, which is therefore of inferior quality. Ripple marks are clearly evident on a smoothed tangential surface The wood is odourless and has an intensely bitter taste

Histology. The wood shows a storied arrangement, the storeys being from 250 to 500 microns in height. The vessels have very numerous,

closely arranged, minute bordered pits, having elliptical or hexagonal borders and slit-like pores; the vessel segments are from one to five times as long as broad. The bulk of the wood is composed of fibres which are

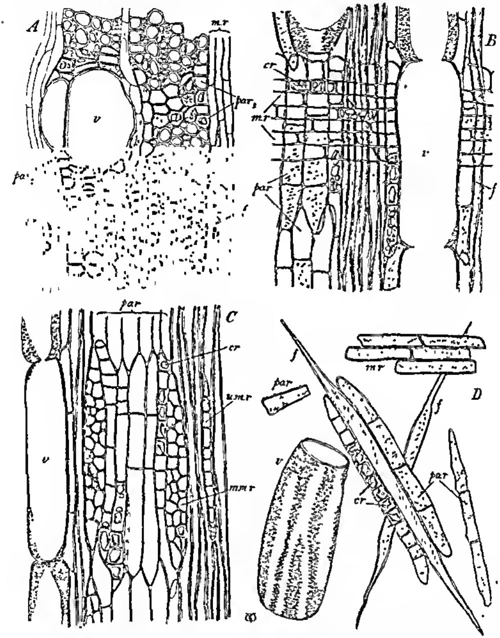

FIG. 16. Wood of *Picræna excelsa*, quassia wood. *A*, transverse section. *B*, radial longitudinal section. *C*, tangential longitudinal section. *D*, cell elements from disintegrated wood. All × 160. *cr*, prism of calcium oxalate; *f*, xylem fibres; *m.r.*, medullary ray; *m m.r.*, multiseriate medullary ray; *par*, xylem parenchyma; par_1, metatracheal parenchyma; par_2, paratracheal parenchyma; *u.m.r*, uniseriate medullary ray; *v*, xylem vessel.

arranged in radial rows, the wide parts of the fibres corresponding in length with the height of the stories and the tapering ends extending into the stories above and below, so that in transverse sections, the mass of

fibres appears to consist of alternate rows of larger and smaller elements; the fibres have narrow, oblique, slit-like pits. The metatracheal parenchyma of the tangential bands is in layers three to seven cells thick and is arranged in vertical files each usually of four cells, excepting the cells
r cells are in files of the same
livided into numerous sub-
calcium oxalate. The files
of crystal cells usually occur adjacent to the fibres; each crystal is surrounded by a closely fitting lignified envelope. The ordinary cells of the parenchyma are sub-rectangular and their walls have numerous rounded simple pits except where they adjoin vessels or fibres, they may contain starch grains, usually in small numbers and about 4 to 12 to 20 microns in diameter. The medullary rays are almost homogeneous, the edge cells being sometimes slightly elongated in a vertical direction; here and there a cell is subdivided into smaller cells each containing a prism of calcium oxalate; the walls bear numerous simple pits and some

Constituents. According to Massute (1890), Jamaica quassia wood contains two closely allied, crystalline, bitter principles, *α-picrasmin*, $C_{35}H_{46}O_{10}$ (m.pt. 204°), and *β-picrasmin*, $C_{36}H_{48}O_{10}$ (m.pt. 209° to 212°), which are to be regarded as the active constituents; it contains further, a very small amount of a crystalline bitter principle melting at 234°, as well as a minute quantity of a yellow crystalline substance which exhibits in acidified alcohol a magnificent blue fluorescence. It contains no tannin. Aqueous extract varies from 6·3 to 8·6 per cent.

Uses. Quassia is used as a non-astringent bitter tonic. It is also used to destroy parasites such as pediculi. Large quantities of quassia are used in horticulture for the destruction of aphides, such as the hop aphis and the woolly aphis, thrips and red spider. Cups turned from the wood were formerly in use under the name of bitter cups.

Substitutes. *Surinam quassia* is usually in smaller billets than Jamaica

free from crystals of calcium oxalate. The bitter principles contained in Surinam quassia are distinct from those of Jamaica quassia, and have been called "quassiins" (Massute, 1890)

Exhausted quassia which has been redried yields a low aqueous extract, about 2·7 per cent.

GUAIACUM WOOD. Lignum Guaiaci, Lignum Vitæ

Sources, etc. The lignum vitæ or guaiacum wood of commerce is derived from *Guaiacum officinale* Linn., and *G sanctum* Linn, family Zygophyllaceæ, both evergreen trees, the former a native of the West Indian Islands and the north coast of South America, the latter of southern Florida and the Bahamas. Both occur in Cuba and *Hayti*, whence the wood is largely exported. The Spaniards became acquainted with the drug when they conquered San Domingo; it was soon brought to Europe, where it acquired an immense reputation in the sixteenth century as a cure for syphilis and certain other diseases, the resin extracted from the trunk being introduced subsequently.

Collection. The trees are felled, the bark stripped off, and the wood exported in logs varying commonly from 1 to 2 metres in length and from 10 to 50 cm. in thickness.

Description. The logs are exceedingly hard, heavy, and compact, and consist of a dark, greenish-brown heartwood surrounded by a yellowish sapwood. The exterior is yellowish-brown in colour and either smooth or furrowed, the furrows being oblique and varying in direction (corresponding to the arrangement of the xylem fibres in the wood). The wood has a density of 1·16 to 1·4 and therefore sinks in water.

The medullary rays are very numerous, about nineteen to twenty-three per millimetre, fine and straight; the vessels are usually single or in

arrangement of the fibres. Both these and the vessels—in fact, all the elements of the heartwood—are filled with a dark resin, which is sometimes also found in cavities in the trunk. It exhales, when warmed, a faint aromatic odour, recalling benzoin, and has, when chewed, an acrid taste.

pale yellow sapwood. The sapwood contains about 3 per cent. of resin, not identical with the resin of the heartwood.

Histology. The elements of the wood are arranged in stories, which are from 70 to 110 microns high. The vessels are up to 150 microns wide and usually extend from one medullary ray to the next; they are isolated or rarely in groups of two, the walls are closely covered with very small bordered pits and the lumen is filled with masses of yellowish resin. The xylem fibres form the mass of the wood, they have very thick walls and are wavy longitudinally, the waves of the fibres in successive tangential

about 20°; the

that the fibres

the fibres gives

rise to the interlocked grain and to the difficulty experienced in splitting the wood. Xylem parenchyma is scanty and is scattered irregularly or occurs in very short tangential bands one cell wide, the files consisting of two cells or sometimes of three or four. The medullary rays are uniseriate and are 3 to 4 to 5 cells high, occasionally they are two cells wide at the middle; in transverse section of the wood they are straight except where they bend to pass round the larger vessels. Resin occurs in all the elements of the wood and prisms of calcium oxalate in some of the cells of the parenchyma. Very occasional starch grains are present in the medullary rays and the parenchyma.

Constituents. The heartwood of guaiacum contains between 20 and 25 per cent. of resin, which consists chiefly of α- and β-guaiaconic acids, guaiaretic acid, and guaiacic acid. Guaiaconic acid is converted by oxidising agents into guaiac-blue, and accordingly tincture of guaiacum wood gives a deep blue colour with dilute solution of ferric chloride, a reaction which is useful in identifying the wood. Guaiacum wood also

acid, though a characteristic constituent of the wood, has been found in other woods (*e.g.*, species of ***Bulnesia*** and *Porlieria*), and its presence therefore is not an infallible diagnostic character of guaiacum wood.

Uses. Guaiacum has a local stimulant action which is sometimes useful in sore throat. The resin is used in chronic gout and rheumatism, whilst the wood is an ingredient in the compound concentrated solution of sarsaparilla, which was formerly much used as an alterative in syphilis.

Substitutes, etc. Commercial guaiacum wood turnings frequently contain the sapwood as well as chips of other woods. These may be detected by their colour and by the amount of alcoholic extract which should not be less than 22 per cent.

RED SANDERS WOOD. Red Sandal Wood, Lignum Pterocarpi

Sources. Red sanders wood is the heartwood of *Pterocarpus santalinus* Linn. filius, family Leguminosæ, a small tree indigenous to Southern India and the Philippine Islands During the Middle Ages it was classed as a spice and used for culinary purposes, and at one time it was supposed to possess medicinal properties; it is now employed solely as a colouring agent.

The tree is regularly cultivated in districts situated to the west and north-west of Madras. The felling of the trees is controlled by the inspectors of forests, and the revenue thus obtained is considerable. The dark red heartwood alone is exported.

Description. Red sanders wood is imported in irregular, often branching billets, commonly 7 to 15 cm. thick and about a metre long, deprived of both the rugged bark and the pale sapwood. It is of a deep blood-red colour both internally and externally, the transverse section exhibiting alternating darker and lighter zones. The medullary rays are just visible under the lens, the vessels are large, mostly isolated, and connected by fine, bright red lines (wood parenchyma). The wood is very hard, but can be easily split It is inodorous, but has a very slight astringent taste.

[illegible] matter is produced in the form of [illegible]

[illegible]

substances, the chief of which are santalin and desoxysantalin. Santalin (santalic acid), $C_{15}H_{14}O_5$, has been obtained in blood-red microscopic needles melting at 226°, it is insoluble in water, but yields a blood-red solution with alcohol, yellow with ether, and violet with caustic alkalies. Santal (Weidel, 1869), pterocarpin, and homopterocarpin (Cazeneuve and Hugouneng, 1887, 1890) are colourless crystalline substances also contained in red sanders wood.

Use. Red sanders wood is used solely as a colouring agent, and [illegible] application, as the colouring [illegible] and is precipitated when the [illegible]

LOGWOOD. Lignum Hæmatoxyli

Sources. The logwood tree, *Hæmatoxylon campechianum* Linn, family Leguminosæ, is indigenous to Central America, but naturalised in the West Indian Islands. The use of the wood as a dye was probably known

to the Mexicans, for its introduction into Europe followed closely on the conquest of Mexico by Cortés; in 1746 it was introduced into the London Pharmacopœia as a mild astringent, but is now rarely used medicinally.

Collection and Preparation. The wood is exported in the form of billets and logs from which both bark and sapwood have been removed; the heartwood alone contains the colouring and astringent principles. It is cut by machinery into chips or turnings which are sometimes fermented by moistening them, heaping them together, and exposing them to the air for a period of from four to six weeks, the heaps being frequently turned over; they are then dried. By this process the chips darken in colour and exhibit patches of a dark beetle-green lustre. For medicinal use unfermented chips are preferred. Fermentation of logwood is not much practised now, as it has been found that the oxidation of the hæmatoxylin to hæmatein that is necessary in the dyeing process can be effected by using an oxidising mordant such as potassium dichromate.

Description. Logwood consists of the heartwood of the tree, imported [illegible] 1 to 2 or more metres in [illegible] or purplish-red colour, [illegible] and heavy, but easily split. The transverse section exhibits under the lens very narrow and closely approximated medullary rays and narrow concentric dark zones alternating with paler ones, a difference due to the colouring matter secreted in the former. The odour of the chips is faint but pleasant, recalling that of violets; the taste is sweetish and astringent. Small fragments impart a purplish blue colour to lime water.

Constituents. The principal constituent of unfermented logwood is hæmatoxylin, $C_{16}H_{14}O_6$, $3H_2O$, of which it contains about 10 per cent. This, when pure, forms colourless crystals which acquire a reddish colour on exposure to the air. It is sparingly soluble in water, but dissolves readily with purple coloration in solutions of caustic or carbonated [illegible] takes place during the fermentation of logwood, the hæmatoxylin being partially converted into hæmatein. Hæmatoxylin is hydroxybrasilin (see below) and hæmatein hydroxybrasilein.

Logwood contains, further, tannin, resin, quercetin, and a trace of volatile oil. The sweetish taste is produced by the hæmatoxylin, the astringency by the tannin.

Varieties. Several commercial varieties of the wood are recognised, that from Yucatan (Campeachy) being considered the best, while British Honduras and San Domingo also furnish wood of good quality; Jamaica logwood is less esteemed, as it is inferior in colouring power. Bastard logwood is the name given to a variety of the wood of paler colour and much less colouring power than the genuine; it appears to be derived from a variety of *H. campechianum*.

Uses. Logwood is largely used as a dye and in the manufacture of inks. Much of it is converted for these purposes into an aqueous extract [illegible] differential staining of cellulose tissues.

SAPPAN. Sappan

Sources. Sappan is the heartwood of *Cæsalpinia Sappan* Linn., family Leguminosæ, a tree indigenous to India and the Malay Archipelago.

Description. The wood occurs in hard, heavy billets of varying size, usually 2 to 6 in. or more in diameter, consisting of the orange-red heartwood to which a little of the whitish sapwood still adheres. Sometimes the wood is reduced to orange-red chips. The transverse section exhibits well-marked concentric rings, numerous narrow medullary rays, and large

colour to lime water (compare Logwood).

Constituents. Sappan wood contains brasilin (see below)

Note. *Brazil wood* is the heartwood of *Cæsalpinia brasiliensis* Linn., Brazil, Guiana, West Indies, &c., and other species. Outer surface (after exposure to the air) dark reddish or nearly black, the freshly cut surface reddish-brown; vessels smaller than in sappan; decoction coloured carmine by alkalies; contains brasilin, $C_{16}H_{14}O_5$, yellowish, which in alkaline solution readily oxidises to brasilein, $C_{16}H_{12}O_5,H_2O$, deep red.

Peachwood is the heartwood of *C. echinata* Lamarck, and also contains brasilin.

Fustic from *Chlorophora tinctoria* Gaudich, family Moraceæ, South America, contains a yellow colouring matter morin or moric acid, $C_{15}H_{10}O_7$,

allied to morin.

CHAPTER VII

BARKS

Barks consist of the external tissues of stems or roots removed by peeling them after making suitable longitudinal and [illegible] incisions through the outer layers. When [illegible] which is usually carried out in the spring, [illegible] at the weakest layer This weakly cons[illegible] is the cambium, because at this position the cells, being in a state of active division, are all very thin walled and therefore easily ruptured. The inner surface, therefore, of a bark corresponds to the position of the cambiform tissue, which has been torn during the removal of the bark, and, proceeding from within outwards, there may be present in the commercial product some or all of the following tissues, viz., secondary phloem, primary phloem, cortex and periderm, by which one understands the phellogen and the products of its activity, such as cork and phelloderm Epidermis is present in very young barks only, and is not usually found in commercial barks; when present it appears as a very thin glistening membrane, giving a somewhat silvery appearance to the pieces of bark. This delicate skin separates quite easily because there is invariably a formation of cork beneath it. The external tissues of older barks often have a rugged and scaly appearance, due to the splitting away, or **exfoliation**, of some of the outer tissues, a condition brought about by the formation of phellogens of local extent and often concave in form, which cut out more or less lenticular masses of cells. The tissues so cut out are, at first, cortex, while later mainly secondary phloem and all such tissue isolated by cork rapidly dies and often flakes off at the position of the phellogen. Layers of dead phloem alternating with bands of cork frequently form a somewhat massive external covering to a bark, and a composite dead tissue of this type is termed a **rhytidoma**.

Many barks, such as cinchona, were originally obtained from trees growing wild, and the usual method of collection was that known as **felling**. The fully grown tree was cut down near the ground level and the bark removed from both stem and branches; this method is rarely used at the present time. In the case of cinchona, it was found that the bark of the root contains alkaloid in notable amount, and, consequently, in plantations of **Cinchona**, the method of **uprooting** has now been largely adopted. The tree at an age of from ten to fifteen years is cut down and the root is dug up; the bark is then removed from the trunk and branches and also from the root. A second method of treatment which is followed is known as **coppicing**. The trees are allowed to grow to an age varying from about three to eight years for tropical trees such as cinnamon and cinchona, and up to twelve or as much as thirty years for slower growing trees such as oak, the stems are then cut down to within a short distance from the ground and the bark is removed from the trunk and branches. The stools, i.e. the stumps which remain in the ground, are allowed to send out a certain

number of shoots, which are re

of from one and a half to seven

and the bark is stripped from

shoots and the plantation will yield regularly for a long period of years.

The time of collection is usually spring or early summer, when the sap is rising in the stem and the cambium is active and, therefore, more easily torn than at other seasons. If there is a rainy season, it is during that period that the bark is most easily collected, as is done with cinnamon. Occasionally a bark is collected at some other time, and this is the case with wild cherry bark, *Prunus serotina*, which is removed in the autumn because at that season the amount of active principle present is greatest. For the removal of the bark longitudinal incisions are made at intervals round the circumference of the stem and the bark is stripped off in long pieces, as is done with cascara sagrada, or longitudinal incisions are made and also horizontal ones at intervals of about 30 cm. and the pieces removed as for cinnamon Bark is also sometimes whittled off with a knife, such as a draw-knife, producing pieces of fairly small size and often showing adherent wood on the inner surface. Drying of barks is nearly always effected by the sun's heat in open air, or sometimes, after a preliminary drying in the open, the operation is completed by some kind of artificial heat.

Barks are characterised by certain peculiar structural features for which special terms of description are used. The shape of the pieces

under pressure, so that

of considerable thickne.

they are found in both

mercial bark is that removed from the smaller branches and it becomes

longitudinal direction ; curvature mostly takes place transversely, and since the inner tissues are softer than the outer ones and occur in considerable masses between the strands of fibres, there is a greater shrinkage in the inner than in the outer tissues, resulting in curvature of the bark with the inner part on the concave surface According to the extent of this curvature different characteristic shapes are assumed and special terms are used to describe them. When only slightly concave on the inside, the pieces are termed curved, and if the concavity is on the outside, as occurs in rare instances, recurved. When the

independently into a quill the piece is a double quill. When quills are packed one inside the other, as is done with cinnamon and sometimes with cinchona, compound quills result.

The colour and condition of the outer surface afford useful characters; when the cork is evenly developed, a smooth surface results, and this is frequently marked by lenticels which are commonly elongated and

placed transversely to the long axis of the bark, as in cascara and wild cherry bark. The presence of rhytidoma gives a scaly appearance, though this is often absent in such barks as quillaia because the outer dead tissues are removed during the preparation of the bark. The corky layer frequently flakes off, or **exfoliates,** in fairly large pieces, exposing the cortical layer beneath; this happens in the calisaya variety of cinchona, where the exposed surface is dark brown and in wild cherry bark where the exposed layer is green or in older specimens cinnamon brown. **Cracks and fissures** of characteristic type arise in the outer surface owing to the lack of elasticity in the dead tissues and the continued increase in girth of the tree; these cracks are often characteristic, having, for example, clean cut edges in *Cinchona succirubra*, but thickened, recurved edges in *Cinchona officinalis.* On older barks small circular dusty patches frequently develop in the cork, and these are described as corky warts, a good example is the older bark of *Cinchona succirubra.* The shrinkage of barks during drying occurs chiefly transversely, because the longitudinally directed fibres tend to prevent extensive shrinking in length and the greater shrinkage of the softer tissues results in the formation of **wrinkles** externally; if the troughs between the wrinkles are very wide, they are termed **furrows.** An additional character is sometimes provided by the presence of **epiphytes** upon the outer surface, most commonly lichens or bryophytes, including both liverworts and mosses, see Fig. 20, B and C.

Lichens are recognised by their greyish colour and thalloid structure or, if they are of the crustaceous type, by [illegible] surface they give to the bark and by the presence [illegible] which are the apothecia or fructifications [illegible]

Liverworts on barks are usually foliaceous and consist of a very slender stem to which small leaves are attached so as to lie all in one plane, giving the plants a dorsi-ventral structure. The leaves are only one cell in thickness and show no central thickening or midrib. See Fig. 20, p. 76.

Mosses have a slender stem bearing spirally arranged leaves, which possess a midrib and have a lamina one cell thick; the margins of the leaves sometimes bear characteristic teeth. See Fig. 20, p. 76.

The inner surface of pieces of bark also shows features of colour and condition which are of diagnostic value. The shrinkage results in the production of parallel longitudinal ridges, which are sometimes very fine and in other cases quite coarse; they are termed **striations.** Occasionally, also as in cascara, longitudinal shrinkage produces parallel transverse wrinkles, known as **corrugations.** Very unequal shrinkage of portions of differing hardness associated with an anastomosis of the fibrous strands, sometimes produces a network of raised lines as in wild cherry bark. When the whole of the innermost tissue is uniformly soft for some little thickness as in quillaia bark, it dries to form a firm dense layer giving a very hard smooth inner surface which emits a metallic sound when sharply struck with a hard instrument.

The behaviour of barks when broken across transversely and the appearance of the exposed surfaces are known as the **fracture,** and this provides one of the most useful diagnostic characters. When the

fractured surfaces are smooth, the fracture is described as **short**; if the surfaces exhibit small rounded prominences, it is **granular**; if jagged projecting points are formed, the fracture is **splintery**; if fine fibrous threads extend from the broken surfaces, it is **fibrous**, and if the fractured region breaks into tangentially arranged layers, as in quillaia, it is **laminated.** The arrangement of the tissues in barks is largely responsible for the type of fracture, and the arrangement can be best seen in the smoothed **transversely cut surface**, which affords a further valuable diagnostic character for most barks.

The **constituents** to which barks owe their action are very various. Nearly all barks c[illegible] euonymus and c[illegible] stituents are vola[illegible] calcium oxalate. F[illegible] chemical reactions [illegible] or to extracts ma[illegible]; used in this way they afford useful identification characters, especially for powdered barks and also when examining them for exhausted material. Examples of such tests are those for tannin, general tests for alkaloids, tests for anthraquinone glycosides, cyanophoric glycosides and quinine.

Histology of Barks. From what has been written above, it is evident that the greater part of all commercial barks consists of secondary phloem which is composed of elements of several types; these are sieve-tubes, often with companion cells; phloem parenchyma, usually also phloem fibres and sometimes stone cells, the whole being traversed radially by medullary rays. **Sieve-tubes** constitute the most characteristic element of the phloem, and as a type of this one may use the well-developed sieve-tube of *Cucurbita*. The sieve-tube is a vessel or long tube formed by several large prismatic or cylindrical cells united end to end. The walls are cellulosic and the cross-walls are at right angles to the tube and are perforated by comparatively large holes, eaten away by the action of enzymes, thus forming the **sieve-plates** which give the name sieve-tube to this type of vessel. [illegible]

[illegible] with minute starch grains. After reaching a certain age, sieve-tubes become blocked by the formation of plugs of a hemi-cellulosic substance, termed **callus** or **callose**, which is formed by the protoplasm and is deposited upon the sieve-plates. In the majority of cases this permanently closes the tubes; the lining layer of protoplasm then disappears and they finally become collapsed owing to the pressure due to the continued formation of new layers of secondary tissues internal to them. In a few plants, the sieve-tubes may function for several seasons, the callose forming in the autumn and being dissolved away by enzyme action in the spring, so reopening the sieve-tubes; this happens in the grape vine and the barberry. After a few years these exceptional tubes become permanently closed, empty and dead. The callus of sieve-tubes is stained a bright pink by corallin-soda, which is a reagent made by adding one volume of a 5 per cent. solution of corallin in alcohol to 20 volumes of a 25 per cent. solution of crystalline sodium carbonate. This reagent also stains lignified tissue, starch grains and some forms of resin and mucilage. Sieve-tubes commonly occur in tangential bands so that the walls of a number of collapsed tubes

form an irregular hyaline band, as seen in sections; and this modified tissue is described as **ceratenchyma** because of its translucent horny appearance. Sieve-tubes of the type described are accompanied by long narrow cells with dense cytoplasm and large nuclei; these are named **companion cells,** and their end walls usually coincide with the ends of the segments of
same initial
with the sie
section they are triangular in shape and are situated in the angles of the large sieve-tube elements, which are polygonal in shape. See Fig. 17.

Three chief **types of sieve-tube** occur in plants; that typical of the gymnosperms has no definite end walls to its segments which taper to bluntly pointed ends, and the sieve areas are small and numerous and are scattered irregularly over the radial walls; they have no companion cells. Amongst the more primitive arboreal dicotyledons, the sieve-tube segments have flat end walls which are inclined obliquely to the side walls; these end walls bear several well-developed sieve areas and there are other usually less well-formed sieve areas on the side walls; these sieve-tubes also are not accompanied by companion cells; such sieve-tubes occur in cascara. The third type of sieve-tube is that already described, having transverse walls at right angles to the side walls and sieve plates upon the end walls only; they are characteristic of herbaceous dicotyledons and of monocotyledons.

Phloem parenchyma consists of cellulose-walled cells which are more or less rectangular in transverse section and somewhat elongated axially; they have large nuclei, abundant cytoplasm and usually contain small starch grains These cells are arranged in vertical files very similarly to xylem parenchyma. When bundles of phloem fibres are present, the parenchymatous cells adjacent to them are commonly subdivided into smaller cells each of which contains a prism of calcium oxalate. **Phloem fibres** closely resemble xylem fibres; they are usually very heavily thickened and possess a narrow lumen; their walls may be cellulosic as in mezereon bark and slippery elm bark, where, however, the middle lamella is lignified, or they may be strongly lignified as in cinchona and cascara. These fibres are present in the majority of barks, but are absent from a few,

point :—

Phloem fibres from	Width	Length
Cinchona	*30–60–90μ*	*500–800–1,350μ*
Cascara	*8–18–27μ*	*380–525–780μ*
Cinnamon . . .	*12–22–35μ*	*200–500–650μ*
Sassafras	*15–25–40μ*	*150–300–480μ*

Their **arrangement** also varies and is often characteristic; for example, they occur isolated or in short radial rows in cinchona; isolated or in short tangential rows in cassia and cinnamon; in tangential bands four or five rows deep and reaching from one medullary ray to the next in witch-hazel, cascara and quillaia.

Sclereids, stone cells or sclerenchymatous cells occur in the parenchyma of many barks. These cells are parenchymatous elements and may be rounded, polyhedral or prisme
lumen may vary from a narrov
sub-rectangular cavity. The
perforated by tubular pits, which are often branched. These external

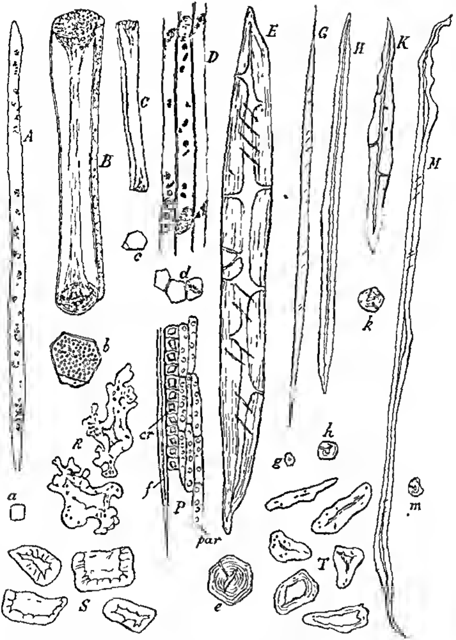

FIG 17. Cell elements from barks All × 200 Sieve-tubes of *A*, *Pinus sylvestris*; *B*, *Cucurbita pepo*, *C*, *Cinchona succirubra*. *D*, *Rhamnus purshianus* Phloem fibres of *E*, *Cinchona succirubra*. *G*, *Rhamnus purshianus*, *H*, *Cinnamomum zeylanicum*; *K*, *Sassafras variifolium*, *M*, *Quillaia saponaria*; *a*, *b*, *c*, *d*, *e*, *g*, *h*, *k*, *m*, transverse sections of the foregoing fibres. *P*, phloem parenchyma of *Rhamnus purshianus*, some cells with circular pits and others with prisms of calcium oxalate. Sclereids of *R*, *Prunus virginiana*, *S*, *Cinnamomum zeylanicum*. *T*, *Rhamnus purshianus*.

openings of the pits appear as small circular or irregular pores dotted over the surface of the cells seen in surface view. The value of these cells for diagnostic purposes is illustrated by the fact that they are absent from frangula bark, but present in the very similar cascara bark; they are few in quillaia and very numerous in cinnamon and cassia.

The **medullary rays** are composed of parenchymatous cells which tend to be elongated radially, and generally have cellulose walls. In some plants, such as *Coscinium*, the prir [illegible] while in others, such as cascara [illegible] ear as the rays become older, p [illegible] imary medullary rays, continuous with those of the xylem which penetrate to the pith, widen as they approach the cortex, the increase being brought about by tangential and radial division of the cells of the original rays, thus enabling them to keep pace with the extension of the outer region in circumference as secondary growth proceeds. The secondary rays are more numerous towards the cambium and the outer rays of each group often bend towards the central line as they approach the cortex, forming roughly triangular groups. At the apex of such triangular groups one may find the **primary phloem** consisting of collapsed sieve-tubes and parenchyma.

Beyond the phloem is the **pericycle**, the outermost stelar tissue; this varies in extent, being sometimes a cylindrical sheath one layer of cells in thickness, as in *Lobelia*, while in other plants the sheath may be many cells thick as in cinnamon, hamamelis and barberry. The pericycle may be parenchymatous and thin-walled throughout, but frequently it includes sclerenchymatous elements; in canella bark isolated fibres occur at intervals, in cinnamon and hamamelis the tissue consists of a band of several rows of sclereids external to which are fibres in small isolated groups. These pericyclic fibres are often less lignified than phloem fibres, and, in transverse section, the lumen is more rounded in outline and the walls highly refractive.

Cortex is often entirely absent from commercial barks, either because it has been cut away, as in cinnamon and quillaia, during the preparation or because it has exfoliated after the formation of a layer of cork. When present, the cortex consists of parenchyma which is often divisible into an outer collenchymatous region and an inner thin-walled region. The cortex usually contains starch and frequently also calcium oxalate, most commonly in cluster crystals, and secretory structures. Secretory structures also often occur in the phloem, for example, oil cells in cinnamon and cassia, mucilage cells in slippery elm, latex cells in euonymus, latex tubes in alstonia and cascarilla, latex vessels in lobelia.

Phellogen or cork-cambium arises in stems, either in the outer epidermis, as in *Salix alba*, *Solanum Dulcamara* and *Viburnum prunifolium* or in the sub-epidermal layer, as in *Quillaia Saponaria*, *Cinnamomum zeylanicum*, *Cinchona*, Cascara and *Alstonia*, or occasionally in the pericycle as in *Berberis*. The phellogen cuts off cells on the outside, the walls of which become suberised and form the tissue known as cork or phellem. Cork cells are therefore in regular radial rows and are usually thin-walled; sometimes they become lignified or both lignified and thickened as in cassia bark and larch bark. In cascarilla bark the walls are lignified and the inner walls are incrusted with small prisms of calcium oxalate. On the inside the phellogen gives rise to rows of cells which are added to the cortex and form a tissue termed **phelloderm**; this tissue may consist of one or two rows only, or it may form a fairly wide band, the cells of which are sometimes sclerotic as in canella bark. The whole of the tissues, cork, phellogen and phelloderm constitute collectively the **periderm**. In older

barks the earliest phellogen ceases to divide and new phellogens are formed in the deeper layers, leading to the death and exfoliation of the cortical tissues, and, finally, when the phellogens dip into the secondary phloem, masses of phloem are cut out and die. There thus arises a dead tissue consisting of alternate layers of dead phloem and cork, a tissue which is termed **rhytidoma** and is found in thicker barks such as cinchona and quillaia. The phellogens are often only local in extent and cause the exfoliation of dead tissues in large flakes, giving the bark a scaly appearance.

The walls of the cork cells are said to be suberised, a change which is brought about by the deposition in the wall of fatty matter, which to a large extent undergoes a change rendering it insoluble in the usual fat solvents such as chloroform; this substance is known as **suberin.** The acids present in the suberin are named suberogenic acids. Corky cell-walls therefore always contain a small amount of fatty matter, soluble in

cent. aqueous solution of caustic potash, the soap appearing as globules

knowledge of the nature of the middle lamella of such tissues is necessary when one wishes to devise methods for their disintegration. This middle lamella is pectic in nature; pectose, pectin and pectic acid are all apparently present and probably also calcium pectate. Pectic acid is an aldobionic acid yielding on hydrolysis galacturonic acid, arabinose and galactose and *possibly also* methyl *pentose. Pectin, which is soluble in* water, is a neutral methoxy ester of pectic acid and is hydrolysed by pectase or by dilute caustic soda to give pectic acid and methyl alcohol. Pectose is a glycosical compound of pectin and cellulose and is insoluble in water. Intermediate between pectin and pectic acid is a group of acids containing different proportions of unchanged methoxy groups; these are termed pectinic acids. Alkaline hydrolysis converts pectose into pectin and cellulose and converts pectin into pectic acids or pectinic acids. All the products of the hydrolysis are present in the form of soluble sodium salts, hence by digestion with a 5 per cent. aqueous solution of caustic alkali, the cellulose tissues of barks may be disintegrated for the study of their constituent cells. If lignified tissues also are present, they may be removed from the alkaline macerate and treated with an oxidising agent as described for the disintegration of woods. During the alkaline digestion the alkali dissolves starch, protein and colouring matter and, after thorough washing with distilled water, the tissues are well clarified for microscopical examination.

Classification of Barks

Barks Possessing an Aroma

A. Aromatic barks with a short fracture: Canella, Cascarilla.
B. Aromatic barks with a short fracture in the outer part; shortly splintery in the inner part: Cinnamon, Oliver Bark, Cassia, Sassafras.
C. Aromatic bark with a very fibrous fracture: Slippery Elm.

openings of the pits appear as small circular or irregular pores dotted over the surface of the cells seen in surface view. The value of these cells for diagnostic purposes is illustrated by the fact that they are absent from frangula bark, but present in the very similar cascara bark; they are few in quillaia and very numerous in cinnamon and cassia.

The **medullary rays** are composed of parenchymatous cells which tend to be elongated radially, and generally have cellulose walls. In some plants, such as *Coscinium*, the primary [illegible] while in others, such as cascara and [illegible] ear as the rays become older, partic [illegible] imary medullary rays, continuous with those of the xylem which penetrate to the pith, widen as they approach the cortex, the increase being brought about by tangential and radial division of the cells of the original rays, thus enabling them to keep pace with the extension of the outer region in circumference as secondary growth proceeds. The secondary rays are more numerous towards the cambium and the outer rays of each group often bend towards the central line as they approach the cortex, forming roughly triangular groups. At the apex of such triangular groups one may find the **primary phloem** consisting of collapsed sieve-tubes and parenchyma.

Beyond the phloem is the **pericycle**, the outermost stelar tissue; this varies in extent, being sometimes a cylindrical sheath one layer of cells in thickness, as in *Lobelia*, while in other plants the sheath may be many cells thick as in cinnamon, hamamelis and barberry. The pericycle may be parenchymatous and thin-walled throughout, but frequently it includes sclerenchymatous elements; in canella bark isolated fibres occur at intervals, in cinnamon and hamamelis the tissue consists of a band of several rows of scleroids external to which are fibres in small isolated groups. These pericyclic fibres are often less lignified than phloem fibres, and, in transverse section, the lumen is more rounded in outline and the walls highly refractive.

Cortex is often entirely absent from commercial barks, either because it has been cut away, as in cinnamon and quillaia, during the preparation or because it has exfoliated after the formation of a layer of cork. When present, the cortex consists of parenchyma which is often divisible into an outer collenchymatous region and an inner thin-walled region. The cortex usually contains starch and frequently also calcium oxalate, most commonly in cluster crystals, and secretory structures. Secretory [illegible]

Phellogen or cork-cambium arises in stems, either in the outer epidermis, as in *Salix alba*, *Solanum Dulcamara* and *Viburnum prunifolium* or in the sub-epidermal layer, as in *Quillaia Saponaria*, *Cinnamomum zeylanicum*, *Cinchona*, Cascara and *Alstonia*, or occasionally in the pericycle as in *Berberis*. The phellogen cuts off cells on the outside, the walls of which become suberised and form the tissue known as cork or phellem. Cork cells are therefore in regular radial rows and are usually thin-walled; sometimes they become lignified or both lignified and thickened as in cassia bark and larch bark. In cascarilla bark the walls are lignified and the inner walls are incrusted with small prisms of calcium oxalate. On the inside the phellogen gives rise to rows of cells which are added to the cortex and form a tissue termed **phelloderm**; this tissue may consist of one or two rows only, or it may form a fairly wide band, the cells of which are sometimes sclerotic as in canella bark. The whole of the tissues, cork, phellogen and phelloderm constitute collectively the **periderm**. In older

Constituents. Canella bark contains about 1 per cent. of volatile oil which has a pungent aromatic taste and contains eugenol, cineol and terpenes. The bitter principle has not yet been isolated, and it is doubtful whether the pungency is due entirely to the volatile oil. The bark contains [illegible] lished from [illegible]

CASCARILLA BARK. Cascarilla, Cortex Cascarillæ

Source, etc. Cascarilla bark is obtained from *Croton Eleuteria*, J. J. Bennett family Euphorbiaceæ, a shrub or small tree indigenous to the Bahama Islands; it is exported from Nassau.

Description. Cascarilla bark occurs in single quills or channelled pieces, from about 5 to 10 cm. in length and 4 to 6 mm. in width. The outer layer of the bark is a white or greyish-white cork which owes its characteristic chalky appearance to the presence of numerous crystals of calcium oxalate in the cells; it is longitudinally wrinkled, and often, at more distant intervals, both longitudinally and transversely furrowed, thus assuming a chequered appearance; it frequently bears the minute black apothecia of lichens, and easily exfoliates, disclosing a brown or dark grey cortex, marked with furrows corresponding to those in the cork. The inner surface is dark brown and longitudinally striated. The fracture is short and resinous. The section exhibits a pale cork layer and a dark brown cortex and phloem, the latter being traversed by numerous very thin whitish medullary rays.

Odour pleasant and aromatic; taste aromatic but rather disagreeably [illegible] stems.

Histology. The most diagnostic features are the lignified cork cells with thickened outer walls and small prisms of calcium oxalate, about 3 to 4μ, adherent to their inner walls; the phloem fibres, not over 20μ wide, isolated or in small groups of two to six; the numerous small oil-cells and resin-cells; the latex secretion tubes of the cortex; the numerous cluster crystals and few prisms of calcium oxalate in both cortex and phloem; the numerous small starch grains; and the uniseriate medullary rays. Sclereids are absent.

Constituents. Cascarilla contains about 1 per cent. of volatile oil, a crystalline bitter principle, cascarillin, which is neither alkaloidal nor glycosidal, and at least two alkaloids, viz. betaine and cascarilline, the latter crystallising in prismatic plates, it yields from 7·5 to 10·5 per cent. of ash, siftings commonly affording a higher figure, probably because they contain many fragments of cork rich in calcium oxalate.

Use. Cascarilla is used as an aromatic, bitter stomachic.

Substitutes. *Copalchi bark*, from *Croton niveus* Jacquin (West Indies Venezuela), occurs in long quills, much larger than those of cascarilla. The bark of *Croton lucidus*, Linn (?): the cork is greyish and firmly adherent; the inner surface is striated and pinkish-brown; the transverse section shows numerous groups of sclerenchymatous cells. The barks of several other species of *Croton* have been found in the commercial drug.

CINNAMON BARK. Cortex Cinnamomi

Sources and History. The cinnamon tree, *Cinnamomum zeylanicum* Nees family Lauraceæ, is a small evergreen tree indigenous to and cultivated in Ceylon.

Cinnamon bark appears to have been collected from wild plants and exported towards the end of the thirteenth century. After the occupation of Ceylon by the Portuguese in 1536, the exportation became more regular. In 1770 the cultivation of the tree was successfully carried out by the Dutch, who, as in other cases, made strenuous efforts to retain the cinnamon trade in their own hands, controlling the supply and the price. Soon afterwards the English obtained possession of the island, and the trade in cinnamon was diverted from Amsterdam to London.

Cultivation, Collection and Preparation. Cinnamon is now almost entirely obtained from cultivated plants, which are grown from seed planted in the cinnamon gardens in groups of four or five in holes about 2 metres apart. The situations chosen are sheltered ones at altitudes up to 500 metres, with a damp climate and a high and equable temperature; the soil is sandy with plenty of humus. The trees grow for about four to six years, the ground being kept free from weeds; they are then cut off close to the ground and from four to seven straight shoots are grown from each stock. These shoots, when about two years old, are lopped off, the side branches are trimmed and the leafy tops removed. After rubbing them with a knife handle or piece of hardwood to loosen the bark, the shoots are ringed at the nodes, about 30 cm. apart, with a sharp copper or brass knife, longitudinal incisions are made to connect the rings and the bark is removed in strips. Brass or copper knives are used to avoid the discoloration that steel would cause by reaction with the tannin of the bark. The pieces of bark are made into bundles, which are wrapped in coir matting and allowed to remain for about twenty-four hours, when a slight fermentation occurs, which loosens the outer layers. Each strip is next stretched on a wooden stick and the epidermis, cork and green cortex are removed by scraping with a curved knife. After slightly drying for twenty-four hours, the pieces are sorted and packed one inside the other and are made up into lengths of 80 cm. to 1·2 metres and about 1 cm. in diameter. These compound quills are placed on wicker platforms mised about 1 metre above the ground and are dried, first in the shade of a shed for a day and then for a second day in the sun. The *cinnamon sticks* so formed are made up into bundles of about 15 kilos each. Cinnamon sticks are graded into four or five qualities according to their appearance and aroma. Small pieces of quills and débris produced during the handling of these finer sticks, are sold separately under the names of "*quillings*" and "*featherings*." Bark of the bigger and coarser shoots does not form quills and is removed in rather thick pieces, which are mixed with bark of prunings and of stems which do not peel well and form a product known as "*chips*," which has a less delicate flavour and commands a lower price. Quillings, featherings and chips are all used for the production of oil of cinnamon. A less valuable oil is also distilled from the leaves and petioles.

Description. Cinnamon occurs in long, slender, flexible sticks about 1 metre in length and 6 mm. in width, each consisting of numerous (about forty) channelled pieces or single quills, about 1 to 2 cm. wide when flattened out, skilfully packed into one another, the largest on the outside, so as to form a long stick of compound double quills; such a stick may easily be separated into its component parts after it has been soaked in water. The individual pieces of bark are not more than 0·5 mm. thick and of a dull, pale brown colour. The outer surface is marked with paler, glossy, undulating, longitudinal lines (bundles of pericyclic fibres), and show here and there scars or holes, indicating the insertion of leaves or lateral shoots, but is almost devoid of epidermis or cork, small patches of which occur in depressions.

The inner surface is rather darker than the outer, and finely striated longitudinally. The fracture is short and rather splintery. The transversely cut surface shows an outer pale layer of pericyclic sclerenchyma and an inner dark *phloem*, traversed by fine medullary rays. The odour is delicate, fragrant and aromatic, and the taste warm, sweet and agreeable.

Histology. Excepting for occasional patches of cork and underlying parenchyma, cork and cortex are absent. The outermost layer consists of a continuous band, three or four cells wide, of pericyclic lignified *sclerenchyma*, on the outer margin of which small groups of about six to fifteen *pericyclic fibres* occur at intervals. The pitted sclereids are often more thickened upon the inner walls than upon the other three, giving them a characteristic appearance; they contain a few starch grains. The *sieve-*

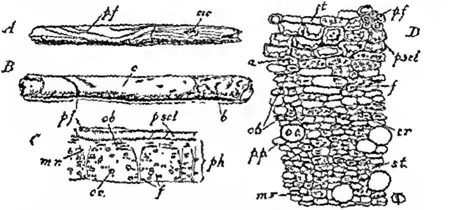

FIG 10 Cinnamon and cassia barks *A*, compound quill of cinnamon × ½; *B*, quill of cassia bark × ½; *C*, diagram of a transverse section of cinnamon × 25, *D*, transverse section of cinnamon × 200. *a*, starch; *b*, outer layers of bark (cork and cortex); *c*, exposed surface of phloem; *cic*, scar left by branch; *cr*, acicular crystals; *ct*, remains of cortex; *f*, phloem fibres; *m r*, medullary ray, *ob*, ceratenchyma; *o.c*, oil cell, *p.f.*, pericyclic fibre; *ph*, phloem; *p p*, phloem parenchyma; *p scl*, pericyclic sclerenchyma; *s t.*, sieve-tubes.

tubes are arranged in tangential bands which are completely collapsed in the outer layers; the sieve plates are on the transverse walls. The *phloem* fibres occur singly or in short tangential rows of two to five; they are lignified, colourless and slender, being about 12 to 22 to 35μ wide and 200 to 500 to 650μ long, their width only rarely exceeds 30μ, which is a distinction from cassia bark. The *parenchyma* consists of sub-rectangular cells which contain starch grains, 5 to 8 to 10μ in diameter, rarely over 8μ, which distinguishes them from the rather larger starch of cassia bark. Some cells contain scattered minute needles of calcium oxalate. *Idioblasts*, somewhat longitudinally elongated, contain volatile oil or more rarely mucilage. The *medullary rays* are usually two-seriate, widening slightly as they approach the pericycle; many of these cells also contain minute needles of calcium oxalate or starch grains, see Fig 10.

The total area of fibres in cinnamon has been measured by the lycopodium method (see *Pract. Pharmacog.*, p. 181 *et ff.*) and amounts to 80 to 85 to 90·5 sq. cm. per gram of the air-dry bark (Saber, 1940). This value can be used to determine the proportion of cinnamon in mixed powders and to

determine the amount of cinnamon in a mixture of cinnamon and cassia bark in the powdered form, see below under Cassia Bark.

Constituents. The principal constituent of cinnamon bark is the volatile oil, of which it yields 0·5 to 1·0 per cent.; the bark contains also tannin and mucilage. Inferior qualities are generally more mucilaginous and contain a volatile oil of inferior fragrance. The drug yields about 4 per cent. of ash and from 26 to 30 per cent. of crude fibre.

The volatile oil (sp. gr. 1·000 to 1·030; o.r. $-$ 0·5° to $-$ 1°) contains from 55 to 65 per cent. of cinnamic aldehyde together with eugenol (4 to 8 per cent.), terpenes and small quantities of numerous other bodies.

Uses. Cinnamon is used chiefly as a carminative or as a flavouring agent in astringent powders and tinctures. It has aromatic, antiseptic and mildly astringent properties.

Related Barks. *Jungle Cinnamon.* Obtained from wild plants; the bark is darker, coarser, less carefully trimmed and less aromatic; it closely resembles cassia bark (see below). *Saigon Cinnamon.* Obtained from *Cinnamomum Loureirii* Nees; quills about 15 cm. long, 10 to 16 mm. wide, and 2 to 3 mm. thick; greyish or greyish-brown with lighter patches; warty and ridged; taste sweeter, odour stronger than Ceylon cinnamon *Java Cinnamon.* From *C. Burmanni* Blume; odour less delicate than that of cinnamon; volatile oil contains about 75 per cent. of cinnamic aldehyde; used in Holland; the cells of the medullary rays contain small tabular crystals of calcium oxalate, whereas in cinnamon they contain minute needles. *Oliver bark*, or *Black Sassafras*, is the dried bark of *Cinnamomum Oliveri* Bailey, family Lauraceæ, a tree indigenous to New South Wales and Queensland. It occurs in flat strips about 20 cm. long, 4 cm. wide and 1 cm. thick; outer surface brownish with patches of whitish cork, very coarsely granular or warty; inner surface umber brown, finely striated, satiny. Fracture short, somewhat fibrous. Section exhibits a somewhat thick rhytidome, often separated from the inner part of the secondary phloem by a paler line of cork cells. Odour aromatic, recalling that of sassafras; taste aromatic, bitter and camphoraceous. The chief constituent is a yellow, volatile oil containing safrol, eugenol, cineol and cinnamic aldehyde; the bark also contains tannin. It is used as a substitute for cinnamon.

CASSIA BARK. Cassia Lignea, Chinese Cinnamon

Sources and History. Cassia bark is obtained from *Cinnamomum Cassia* Blume, family Lauraceæ, a medium-sized tree, probably a native of Cochin China, but cultivated now in the south-eastern provinces of China. This [illegible] ese [illegible] try [illegible] to which the name of Cassia vera (or sometimes also Cassia lignea) is given; they are exported from Calcutta and Saigon. The cassia vera of the London market is a firm, rather thick bark with a very mucilaginous taste; it is said to be the bark of *Cassia Burmanni* de Candolle.

The bark is collected entirely from cultivated trees. When about six years old the branches are cut and the small twigs and leaves stripped off; two longitudinal slits are then made, and three or four circular transverse incisions cut at intervals of about 40 cm. The bark is removed in pieces about 40 cm. long and half the circumference of the branch. These are next laid with the concave surface downwards and a small plane passed

over them, by which the cork and part of the cortex are more or less removed. After drying in the shade and sun, the bark is tied up into bundles about 30 or 40 cm. long and weighing about 500 gm. and exported in boxes resembling tea chests, which are sometimes wrapped in bast-mats.

Description. The pieces of bark vary from 5 or 6 to 40 cm. in length and average from 1 to 2 cm. in width and 1 to 3 mm. in thickness. They are either channelled pieces or single quills, of a dark, earthy brown colour and smooth, but with patches of the thin greyish cork still adhering to the outer surface. The fracture is short, the section of the thicker pieces showing a faint white line (pericyclic sclerenchyma) sometimes near the centre, sometimes near the outer margin and parallel to it. In odour and taste cassia bark resembles cinnamon, but it is less delicate in aroma and more mucilaginous and astringent in taste.

Histology. Cassia bark closely resembles cinnamon in structure. It shows, externally to the pericyclic sclerenchyma, a band of cortical parenchyma with sclereids, both isolated and in small groups, and beyond this a layer of cork in which there are bands of two or three rows of cells with thickened and lignified walls, the remaining cork being thin-walled. The cells of the innermost layer of cork have strongly thickened outer walls. Cassia is distinguished from cinnamon by the abundant cork, the wider phloem fibres, which often measure from 30 to 45µ in width, and the larger starch grains which are commonly over 10µ and often reach 20µ in diameter.

The total area of fibres in cassia bark is 11 to 11·75 to 12·5 sq. cm. per gram of air-dry bark (Saber, 1940); this value can be used to determine the amount of cassia bark in mixtures with cinnamon or other spices.

Constituents. Cassia bark yields from 1 to 2 per cent. of volatile oil, resembling that of cinnamon, but having a higher specific gravity (1·050 to 1·070) and containing more cinnamic aldehyde (75 per cent.) but no eugenol. The drug yields 13 to 24·5 per cent. of crude fibre.

SASSAFRAS BARK. *Sources.* *Sassafras bark is the dried bark deprived of most of the cork, of the root of Sassafras varifolium (Salisbury) O. Kuntze, family Lauraceæ, a tree growing in the eastern states of N. America, the bark coming chiefly from Virginia, Tennessee and Kentucky.*

Description. *In curved or recurved, irregular pieces, 0·5 to 3 to 4 mm. thick, 1 to 4 to 15 cm. long and 1 to 3 cm. wide, rarely in quills; outer surface rusty brown and fairly smooth; inner surface somewhat lighter in colour and longitudinally striated; fracture shortly fibrous; texture soft and rather porous; odour strongly fragrant and aromatic; taste sweetish, somewhat mucilaginous, aromatic and slightly astringent.*

Histology. The most diagnostic features are the large, isolated, lignified phloem fibres, about 25µ wide, spindle shaped with acutely pointed ends and about 150 to 300 to 480µ long; the abundant ovoid oil-cells, the numerous rounded starch grains, mostly simple or two- to four-compound, individual grains being from 3 to 20µ in diameter. In many cells of the parenchyma there are small scattered needles of calcium oxalate.

Constituents. Volatile oil 5 to 9 per cent.; tannin and starch. Oil of sassafras has a sp. gr. 1·07 to 1·09 and contains safrol as its most important constituent.

Uses. Sassafras bark is used as an aromatic and carminative, frequently in association with purgatives containing anthraquinone derivatives.

SLIPPERY ELM BARK. **Cortex Ulmi Fulvæ**

Sources. The slippery elm, *Ulmus fulva* Michaux, family Ulmaceæ, is a small tree indigenous to the central and northern United States. The

bark is collected in the spring from the trunk and large branches, deprived of its outer dead portions, and dried. Large quantities are collected in

... n bark of commerce consists entirely of ... only imported in large flat strips ½ to 1 metre long and 1 to 4 mm. thick. The outer surface is reddish-yellow in colour, with patches of the reddish-brown outer portion (rhytidome), and is distinctly striated longitudinally; the inner surface is tawny-yellow and also longitudinally striated.

It is extremely tough and fibrous. The transversely cut surface is completely traversed by medullary rays, between which small tangential bands of phloem fibres and phloem parenchyma are arranged alternately, giving the surface a chequered appearance. If the transverse surface is moistened and allowed to remain for a minute or two and again examined, numerous cells full of transparent swollen mucilage can be detected. The bark has a strong aromatic and spicy odour resembling fenugreek, and a mucilaginous taste.

Constituents. The principal constituent is mucilage, which swells but does not dissolve in water; it is contained in large cells in the phloem, and is present in such proportions that 1 gm. of the powdered bark will convert 50 c.c. of water into a thick jelly.

Uses. The bark has demulcent and emollient properties. It is used as an external application in the form of a poultice; it is sometimes added to porridge and to infants' and invalids' food.

POMEGRANATE BARK. Cortex Granati

Sources. The pomegranate tree, *Punica Granatum* Linn., family Punicaceæ, is a shrub or small tree indigenous to north-western India, but cultivated generally in the warmer parts of the temperate regions, especially in the countries bordering on the Mediterranean. More than

...

10 cm. long and 1 to 3 cm. wide. The *root-bark* consists of irregular, curved, flattish or recurved fragments, the outer surface is rough, earthy yellow with darker patches and marked by conchoidal depressions, due to exfoliation of the outer part; the inner surface is smooth and yellow, with irregular, darker, brown blotches; the fracture is short, the fractured surface being nearly white and showing, when smoothed, numerous fine tangential and still finer radial lines. The *stem-bark* is in straighter channelled pieces or in quills, conchoidal depressions being absent; the outer surface shows occasional shallow, longitudinal furrows and pale bands of cork and is frequently marked by minute apothecia of lichens, which are absent from the root-bark. Pomegranate bark is odourless, but

... thickened and lignified ... characteristic sclereids, either isolated or in small groups and a very few prisms of calcium oxalate; the phloem shows abundant cluster crystals of calcium oxalate, which occur singly in most of the cells of the tangential bands of parenchyma; the medullary rays are uniseriate and occasional cells contain numerous very small prisms of calcium oxalate. Abundant small rounded starch grains are present in the parenchyma. Phloem fibres are absent.

Constituents. Five alkaloids have been isolated; four, viz. pelletierine, isopelletierine, methylpelletierine, and methylisopelletierine, are liquid, but pseudo-pelletierine is crystalline. The total alkaloid present is about

0·5 per cent. in the stem-bark, and 0·6 to 0·7 per cent. in the root bark (Ewers, 1899). The average of commercial bark appears to be about 0 35 per cent. Carr and Reynolds (1908) found only 0·12 to 0 29 per cent.; other authorities give 0·5 to 0·7 per cent. The freshly-dried bark has been found (in Java) to yield as much as 3 0 per cent., and there are indications that the percentage of alkaloid diminishes on keeping.

Pomegranate bark contains about 22 per cent. of tannin.

Pelletierine ($C_8H_{15}NO$) (Tanret, 1878) or punicine (Bender, 1885), is a colourless liquid boiling at 195°, but rapidly assuming a brown colour. *Isopelletierine* closely resembles it; *methylpelletierine* boils at 215°. *Pseudo-pelletierine* has also been called *n*-methylgranatonine (Ciamician and Silber, 1893). The pelletierine tannate of commerce is a mixture of the tannates of the alkaloids of the stem and root-bark.

Uses. Pomegranate bark has an anthelmintic and slightly irritant action, but is somewhat astringent unless taken freely. It is used in the treatment of tapeworm, which is expelled (not actually killed).

EUONYMUS BARK. Wahoo Bark, Cortex Euonymi

Sources. Euonymus bark is the dried root-bark of *Euonymus atropurpŭrĕus* Jacquin, family Celastraceæ, a tall erect shrub with small dark purple flowers succeeded by crimson fruits; it is common in the eastern United States, extending westward to Wisconsin and southward to Florida The drug usually consists of root-bark, but the stem-bark also is collected.

Description. Euonymus root-bark occurs in small, more or less irregular, quilled or curved pieces, not usually exceeding 8 cm. in length or 12 mm. in width. The outer layer is a soft, spongy, finely fissured cork, of a light ash-grey colour marked with darker lines or patches (due to adhering particles of earth) and occasional, small, transverse scars The inner surface is of a pale tawny yellow or buff colour and nearly smooth; occasionally a thin shaving of pale yellow, dense wood adheres to it.

It breaks with a very short fracture, and if the two pieces be separated very gently from one another delicate silky threads will be seen connecting them; these threads consist of a substance resembling caoutchouc or guttapercha secreted in laticiferous cells in the phloem, and found in all species of *Euonymus*. The smoothed transversely cut surface is greyish-white, and exhibits, when moistened, a narrow whitish cork, a pale cortex, and darker phloem The bark has a faint but characteristic odour recalling that of liquorice root, and a disagreeable and persistent, bitter, acrid taste.

Histology. The bark exhibits a thick layer of narrow thin-walled lignified cork cells, a cortex containing abundant cluster crystals of calcium oxalate and a wide layer of secondary phloem in which are scattered narrow fibre-shaped, laticiferous cells filled with a granular substance and having thin cellulose walls. The bark contains no sclerenchymatous fibres or cells. The medullary rays are one cell wide The parenchyma contains numerous small starch grains

Constituents. A bitter, crystalline alcohol, euonymol ($C_{21}H_{30}O_{8}$), has been isolated from it. From the resin (3 2 per cent) contained in it the crystalline alcohols euonysterol, homoeuonysterol, atropurol and citrullol have been separated. The bark also contains considerable quantities of dulcitol (dulcite), $C_6H_8(OH)_6$, a hexahydroxy alcohol readily crystallising in large plates melting at 188 5°; it has a sweetish taste and has been found in a considerable number of plants The presence of the crystalline glucoside euonymin has not been confirmed.

Uses. Euonymin (the powdered extract) is an hepatic stimulant, direct

cholagogue, and mild cathartic. It is used in constipation and in hepatic derangements.

Substitutes. The stem-bark, which is a commercial article, occurs in long, thin narrow str . . . and fibrous phloem ; . . .

Wafer Ash bark, th . . . been frequently mixed with or substituted for euonymus bark; it is thicker, bears long, transverse, whitish scars; medullary rays three cells wide; below the cork a layer of yellow sclerenchymatous cells; in the secondary phloem large oleo-resin cells.

BLACK HAW BARK. Cortex Viburni Prunifolii

Sources. Black haw bark is the root-bark of *Viburnum prunifolium* Linn., family Caprifoliaceæ, a shrub indigenous to the eastern and central United States of America, chiefly from North Carolina and Tennessee.

Description. The drug occurs in short, quilled, channelled or curved pieces up to 10 cm. long and from 1 to 4 mm. (usually about 2 or 3 mm.) thick, and of a dull brown or reddish-brown colour. In the youngest pieces the outer surface is slightly longitudinally wrinkled, older pieces exhibit small, rounded, or oval lenticels, while in old bark the surface is irregularly wrinkled, fissured, and scaly. Inner surface longitudinally striated, rough and reddish-brown. Fracture short and granular, the fractured surface exhibiting numerous minute glittering points (calcium oxalate). The smoothed transverse surface shows a dark brown cork and a whitish or reddish cortex and phloem, in which numerous pale yellowish groups of sclereids are visible. The odour is slight and resembles that of valerian, the taste bitter and astringent. Portions of the smaller roots often occur in the drug.

Constituents. Black haw bark contains viburnin (a water-soluble bitter glycoside), tannin, resin, and salicylic acid.

Uses. The drug has been used for dysmenorrhœa and asthma; it is supposed to prevent threatened abortion and to check hæmorrhage.

WILD CHERRY BARK. Virginian Prune Bark, Cortex Pruni Virginianæ. Prunus serotina

Sources. The bark that is commonly known as "wild cherry bark," is obtained from *Prunus serotina* Ehrbart, family Rosaceæ, the black cherry, a tree widely distributed over North America, especially throughout the northern and central States; it is collected in the autumn, at which time it is medicinally most active.

Description. Wild . . . usually in flattened, . . . length and 5 cm. in . . . thickness. Young . . . often glossy, reddish-brown cork, much interrupted by whitish, tangentially elongated lenticels; it can easily be peeled off in thin, membranous, tangential strips, disclosing a smooth, greenish-brown cortex. Old bark is darker and rougher. Much of the commercial drug has been deprived of its cork, and then the smooth, greenish-brown cortex, bearing scars corresponding to the lenticels, constitutes the outer layer. Sometimes even this has been removed and the exposed part is then the phloem, which has a rough or rasped appearance and is of a uniform, dark cinnamon-brown colour ("rossed" bark); examined under the lens such bark exhibits pale anastomosing,

longitudinal strands, mainly sclereids, alternating with darker parenchymatous tissue (medullary rays). The inner surface of the bark is of a cinnamon-brown colour and is finely longitudinally striated or rough, with reticulately anastomosing pale strands, the interstices of which are only partially filled with the brown (parenchymatous) tissue of the medullary rays.

The fracture is short and granular; the smoothed transversely cut surface has a reddish-grey colour, and shows an outer narrow, brown layer of cork, followed by a greenish band of cortex with numerous tangentially elongated groups of sclereids, and a tangential band of pericyclic sclerenchyma; the phloem, which in "rossed" bark constitutes the entire drug, exhibits numerous tortuous, pale red medullary rays alternating with phloem rays containing many groups of irregular sclereids; prisms of calcium oxalate are present in the parenchyma.

The dry bark is almost odourless, but after moistening, it develops a strong odour of bitter almonds, the taste is astringent, aromatic, and bitter, resembling that of bitter almonds.

Constituents. Wild cherry bark yields, when moistened with water, hydrocyanic acid and benzaldehyde. This reaction has been shown by Power and Moore (1909) to be due to prunasin (lævo-mandelonitrile glucoside), $C_{14}H_{17}O_6N$, which is isomeric, but not identical with prulaurasin and sambunigrin; it is hydrolysed by an enzyme, prunase, also contained in the bark, yielding hydrocyanic acid, benzaldehyde and dextrose. Thin green bark collected in the autumn yields most hydrocyanic acid (0·12 to 0·16 per cent.); from the commercial drug 0·075 per cent. has been obtained; the bark of the root is said to be more active than that from the stem or branches (Stevens, 1896). The bark contains also a brown resin, trimethylgallic acid, paracumaric acid and traces of benzoic acid and volatile oil; a green resin yielding by acid hydrolysis β-methylæsculetin is also present.

Uses. The bark has mild tonic and sedative properties; it is frequently given for coughs and chest complaints.

Substitutes. The bark of other North American species of *Prunus* is occasionally substituted for the official. The latter is well characterised by its short, granular fracture and distinctive taste, as well as by the presence of abundant sclerenchymatous cells and absence of true phloem fibres. Spurious barks may be fibrous, or more astringent, or almost devoid of taste. Old (trunk) bark is characterised by the numerous depressions on the outer surface and the absence of lenticels.

CASCARA SAGRADA. Cortex Rhamni Purshianæ, Sacred Bark, Chittem Bark

Source, etc. Cascara sagrada is the bark of *Rhamnus Purshiana* de Candolle, family Rhamnaceæ, a shrub or small tree formerly abundant and now cultivated in North California and in the States of Washington and Oregon, the bark being collected in these States and exported from San Francisco. Considerable quantities are also collected from plantations in British Columbia and exported from Vancouver, and the tree has been successfully cultivated in Kenya Colony.

Cultivation, Collection and Preparation. The trees are grown from seed and are ultimately spaced at 1·5 to 2 metres apart. When the trees are from nine to fifteen years old and the stems over 10 cm. in diameter, the bark is collected from them during the dry season from about the middle of April to the end of August; staining and blackening result if the bark is cut during the rainy season. Moss and epiphytes are removed from the tree by scraping and longitudinal incisions are made into the tree-trunk at distances 5 to 10 cm. apart, after which the bark is stripped in long pieces to within about 30 cm. of the soil. The trees are then cut down and the bark removed in strips from the branches. Drying is effected by placing the bark on racks raised about 30 cm. above the ground or by hanging the strips over galvanised iron wires; the inner surface is always turned downwards to prevent the darkening which occurs if it is exposed to the sun. When dry, the strips are broken into smaller pieces and packed into sacks holding from 2·5 to 5 kilos each.

Description. Cascara sagrada occurs in single quills and in curved or channelled pieces. The quills are from 5 to 25 mm. or more in diameter, whilst channelled or flattish pieces may be as much as 10 cm. wide; commonly tho [illegible] wide, and from 1·5 t[illegible]

The outer su[illegible] with transversely elongated whitish lenticels. The bark, however, is often more or less completely covered with silvery grey patches of lichens giving the drug a pervading greyish-white colour; bryophytes, both mosses and liverworts, are often attached to the outer surface. In most samples of the bark, pieces are to be found more or less encrusted with mussel-scale insects. The inner surface is yellow to reddish-brown or nearly black in carelessly dried bark; it is longitudinally striated and shows faint transverse corrugations in some pieces.

The fracture is short in the cork and cortex and shortly fibrous in the phloem. The section (see Fig. 20 D) exhibits a narrow purplish cork, a yellowish-grey cortex in which darker translucent points (groups of sclereids) can be distinguished, and a brownish-yellow phloem traversed by wavy medullary rays. The bark has a slight but characteristic odour, and a persistent, nauseously bitter taste. It should be kept for at least a year before it is used medicinally; the action is then milder and less emetic. It imparts a yellow colour to the paper in which it is kept.

Histology. The *cork* consists of numerous layers of small, thin-walled, flattened, polygonal prisms, arranged in radial rows and having yellowish-brown contents which are coloured purple by the addition of caustic alkali. The *cortex* comprises an outer part of about six layers of collenchymatous cells, and an inner part of many layers of thin-walled cellulosic

[illegible]

pierced by numerous tubular simple pits; the lumen is very small, often reduced to a line. The groups of sclereids are not present in very young bark from shoots up to about 8 mm. thick. All the cells of the cortex, except the sclereids, are somewhat tangentially elongated and contain chloroplasts within which are minute starch grains; occasional mucilage cavities occur in the outer cortex. The *primary phloem* consisting of a few fibres and some collapsed sieve-tubes can often be clearly distinguished

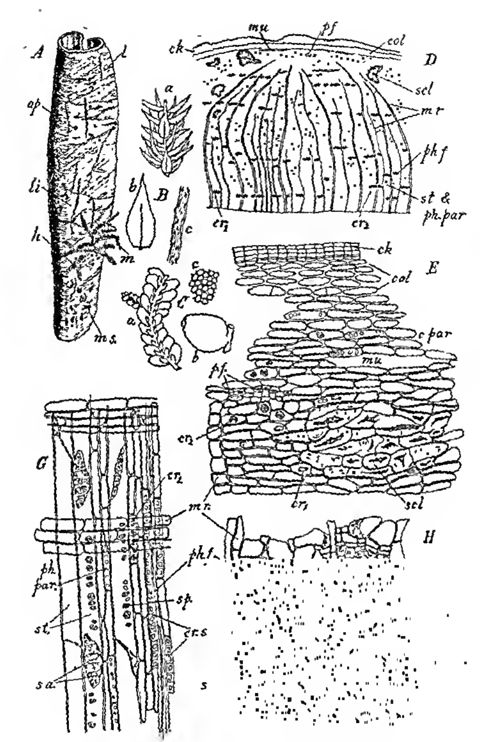
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FIG. [illegible]

near the apex of each of the groups of converging secondary medullary rays. The *secondary phloem* forms the bulk of the bark and is traversed by medullary rays; the primary ones widen in the form of a wedge as they approach the cortex and contain groups of sclereids in the outer part; the secondary medullary rays are usually three- to five-seriate, sometimes uniseriate, and somewhat wavy and arranged in groups between the primary rays so that the rays of each group bend toward a central line as they approach the cortex. The sieve-tubes are in tangential bands which are much compressed in the outer phloem. The flat end walls of the segments of the sieve-tubes are sharply inclined to the long axis and carry three or four well-developed sieve areas; there are sieve areas also on the side walls; there are no companion cells. The phloem fibres are

chyma is in tangential bands alternating with the bands of sieve-tubes and of fibres, and many of the cells which abut upon the fibres contain a prism of calcium oxalate forming a crystal sheath to each group of fibres; in the other cells there are occasional cluster crystals of calcium oxalate. In the outer part, that is, in the older secondary phloem, groups of sclereids develop similar to those found in the cortex. The parenchyma, as well as the parenchyma of the medullary rays, contains yellowish-brown colouring matter which changes colour to purple when treated with caustic alkali, see Fig. 20 E, G and H.

Constituents. The presence of emodin and an allied substance, possibly frangula-emodin, has been definitely proved (Jowett, 1905). The total amount of emodins present in the bark is about 1·4 to 2·0 per cent. The bark also contains fat (about 2 per cent), glucose, and a hydrolytic enzyme. No difference could be detected in the chemical constituents of the fresh (one year old) bark and the matured (three years old) bark. Green, King and Beal (1936 and 1938) and Liddell, King and Beal (1942) have shown that emodin, aloe-emodin and chrysophanol are obtainable from extract of cascara and that though each of these constituents administered separately has little purgative effect, yet the three given in admixture produce a good purgative action. Iso-emodin was also isolated from the extract. The bitter taste appears to be due to a lactone which is converted into less bitter salts by treatment with alkalies or alkaline earths, but this change is accompanied by loss of activity. Cascara bark yields about 27 per cent. of aqueous extract and about 5 per cent. of ash.

The presence of emodins may be shown by the test described under 'Alder Buckthorn Bark,' see p. 80.

Uses. Cascara sagrada is tonic and stomachic in small doses, aperient in large doses, and cathartic if freely given. It has been much used as a laxative since 1883.

Substitutes. The bark of *R. californica* Eschscholz has been described as a substitute, but there is reason to doubt the validity of this species of *Rhamnus*. No chemical difference could be found between the barks of *R. purshianus* and *R. californica* (Jowett, 1905).

ALDER BUCKTHORN BARK. Cortex Rhamni Frangulæ

Sources. The alder buckthorn, *Rhamnus Frangula* Linn., family Rhamnaceæ, is distributed over Europe. It may be distinguished from

the common buckthorn (*R. cathartica* Linn.), the only other indigenous species, by the entire leaves, hermaphrodite flowers with five stamens, absence of thorns, and tree-like habit. The bark is imported chiefly from Holland.

The bark is stripped from the stem and branches, the wood of which was formerly valued for making charcoal for gunpowder. When fresh it has an unpleasant odour and taste, and acts as an emetic, but these properties are lost when the bark is dried and kept; alder buckthorn bark should not therefore be employed medicinally until it has been kept for at least a year.

Description. The drug occurs in single or double quills from about 0.5 to 4 cm. in diameter and 15 cm. or more in length. *Young bark is usually thin and is covered with a smooth, glossy, dark purplish cork marked with small, circular or transversely elongated, whitish lenticels. The cork frequently exfoliates, or at least easily separates, disclosing a yellowish-brown cortex, but the inner part of the cork is of a deep crimson colour easily seen by gently scraping off the outer cork. The inner surface is dark cinnamon-brown and nearly smooth, with fine longitudinal striations.* The fracture is short in the outer, but rather fibrous in the inner, part, *groups of fibres projecting a short distance beyond the fractured surface.* Older bark is rougher externally, of a dull, dark purple colour, and bears *transversely elongated lenticels and shallow longitudinal fissures, the cork* exhibiting less disposition to exfoliate. The bark has a faint odour *resembling that of cascara and a taste that is scarcely bitter.*

Histology. A transverse section exhibits a cork consisting of narrow cells many of which contain a bright purplish-crimson colouring matter. The cortex contains small starch grains, cluster crystals of calcium oxalate and elongated mucilage cavities, but no sclereids. The secondary phloem contains numerous tangentially elongated groups of thick-walled phloem fibres; the medullary rays are mostly two cells wide. The cells of the medullary rays and phloem parenchyma contain a yellowish amorphous substance dissolving in solution of potassium hydroxide with production of a bright purple colour. The structure, therefore, is closely similar to that of cascara sagrada from which it is distinguished by the absence of groups of sclereids.

Constituents. The active constituents are imperfectly known. It contains a glycoside, frangulin, $C_{21}H_{20}O_9$, which crystallises in lemon-yellow needles, is slowly volatile at ordinary temperature and stains the paper in which the drug is kept; it is soluble in caustic alkalies with purple coloration. Boiled with alcoholic hydrochloric acid it is converted into rhamnose and frangula-emodin. Frangula-emodin, $C_{15}H_{10}O_5$, occurs in reddish-yellow crystals melting at 254°; it is a trioxymethylanthraquinone, $C_{14}H_4(CH_3)(OH)_3O_2$, and appears to be identical with rheum-emodin, but different from aloe-emodin and senna-emodin; it has been known under various names, viz. rhamnoxanthin (Buswanger, 1850), frangulin (Casselmann, 1857), avornic acid (Kubly, 1866), frangulinic acid (Faust, 1869, Keussler, 1873). Frangulin is said not to be present in the fresh bark, but to be produced from some unknown constituent during the maturing of the bark, the change in the physiological action occurring simultaneously. The bark also contains free frangula-emodin, chrysophanic acid and an iso-emodin.

The total quantity of oxymethylanthraquinones present in the bark either free or in the form of rhamnosides has been estimated at 1 per cent. in old bark, 2 per cent. in bark of medium age, and 3.8 per cent. in very young bark. Casparis and Maeder (1925) have isolated from the bark about 6 per cent. of an amorphous glycoside, glucofrangulin, which yields by

hydrolysis rhamnose, dextrose and frangula-emodin ; it is more laxative than frangulin and, indeed, sufficiently laxative to account for the action of the drug.

The presence of emodin in the bark is readily demonstrated by hydrolysing the glycosides with dilute sulphuric acid, extracting with an organic solvent such as benzol, or carbon tetrachloride, separating the layer of organic solvent and shaking it with dilute solution of ammonia ; after separating, the ammoniacal layer has a rose-pink colour ; see also p. 320.

Uses. Alder buckthorn bark has been used as an agreeable laxative, preferable to cascara sagrada on account of its less disagreeable taste.

Substitutes. The bark of *R. carniolica* Kerner, is sometimes substituted for that of *R. Frangula* ; the cork contains a dull red, not crimson, colouring matter ; medullary rays four to seven instead of two to three cells wide ; rhytidome, when present, contains groups of scleroids.

The bark of *Alnus glutinosa* Gaertner, family Betulaceæ, exhibits in transverse section a band of pericyclic sclerenchyma.

The bark of *R. cathartica* Linn., is glossy reddish-brown and has very distinct lenticels ; it contains frangula-emodin together with chrysophanol, rhamnosterin, a fluorescent body, rhamnofluorin and a glycoside, rhamnicoside, which yields on hydrolysis dextrose, xylose and crystalline rhamnicogenol (a derivative of oxymethylanthraquinone) ; rhamnicoside does not occur in *R. frangula* (Bridel, 1925).

CINCHONA BARK. Cortex Cinchonæ, Cinchona

Sources and History. The genus *Cinchona*, family Rubiaceæ, comprises numerous species, all of which are indigenous to South America, and grow on the Andes extending from about 10° N. latitude in western Venezuela, through New Granada, Ecuador, and Peru, to Bolivia, about 19° S. latitude, a total distance of about 2,000 miles. Throughout this region, upon the eastern slopes of the main range and its spurs, over a width of thirty-eight to fifty miles, the trees occur at an altitude of about 5,000 to 7,000 ft. in the central region (Ecuador and N. Peru) and about 4,000 ft. in the north and in the south. The [illegible]

temperature ranging from 12° to 20° C.

The natives of Peru and Bolivia appear to have been acquainted with the febrifuge properties of the bark of these trees and to have communicated their knowledge to the Jesuits and the early Spanish conquerors. The bark was brought to Spain, probably by the aid of the Jesuits, and became known as Countess bark, Jesuit's bark, or Peruvian bark, and early in the eighteenth century the trade in it at Loxa (in Ecuador) had assumed considerable proportions. The first variety introduced was the bark of *C. officinalis* ; as the supply fell short, that of *C. succirubra* was exported.

In the year 1736 an expedition was sent by the Paris Academy of Sciences to measure a degree of the earth's circumference at the equator, and it was accompanied by the botanist Jussieu, who found the trees, hitherto unknown to science, that yielded cinchona bark. The botany of these trees was sub[illegible]
(1760), Ruiz and Pavon (1778–1788), [illegible]
The species of *Cinchona* yielding [illegible]

C. Ledgeriana Moens and *C. Calisaya* Weddell, both natives of Southern Peru and Bolivia and now grown in Java and in India, *C. officinalis* Linn., originally from Ecuador and Peru, now cultivated in India, *C. succirubra*, a native of Ecuador, now cultivated in India and on the Portuguese island of S. Thomé off the west coast of Africa. *C. Ledgeriana* is generally regarded as a hybrid between *C. Calisaya* and *C. micrantha*, it yields the variety of cinchona known as Ledger bark. Other hybrid cinchonas are largely grown, the best known being *C. robusta*, which is a hybrid between *C. succirubra* and *C. officinalis* and also hybrids between *C. Calisaya* and *C. succirubra*, which are grown in Tanganyika Territory where the bark so produced is very rich in quinine.

Cultivation, Collection and Preparation. The early bark collectors cut down the trees close to the ground and, after beating the trunk and larger branches to remove much of the periderm, cut through the bark at regular intervals and removed it in pieces about 40 to 50 cm. by 10 to 12 cm.; these were first exposed to the sun and then stacked in crossed layers to form a square pile and heavy stones placed on top, these processes being repeated for several days until the bark was dry and large flat pieces resulted. The bark from most of the branches was not deprived of periderm, but was stripped off and dried in the sun to form large and small quills; the drying was sometimes done over a gentle fire in huts. A valuable and lucrative trade was established and between the years 1630 and 1860 the increasing demand for bark and the careless methods of collection resulted in so great a destruction of trees as to threaten the extinction, in their native habitat, of the useful species of *Cinchona*. Attempts were therefore made to obtain seed or young plants for the cultivation of the trees in other countries. The Indian Government alone was spending about £12,000 a year on quinine, and in 1859 Sir Clements Markham was sent out to Peru and Bolivia and was successful in securing seed of the more valuable cinchonas. As a result of this expedition plantations were established in different parts of India; *C. officinalis* in the Nilgiris of southern India, *C. officinalis* and *C. succiruba* in Madras, and *C. Ledgeriana* at Darjeeling in Sikkim. About the same time, in 1854, Hasskarl, a botanist of Dusseldorf, was commissioned by the Dutch on a similar expedition to Callao and was successful in taking seeds and plants to Java, where the variety grown was chiefly *C. Ledgeriana*. At the present time the Indian plantations supply the needs of India itself, but practically nothing is exported; the Dutch plantations in Java, where the soil and climate are specially suited to the cinchona trees, now supply about 90 per cent. of the world's needs.

For the cultivation of cinchona a piece of forest land, at a suitable elevation, is cleared, broad shelter-belts of trees being left on the ridges.

clearing. Holes are made about a metre apart and the seedlings are transplanted in damp, cloudy weather during the rainy season. About the
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the stools shoots arise and coppicing is continued throughout the life of the

plantation. In some plantations, especially in Java, the method of "uprooting" is adopted instead of "[illegible] to grow to an age of about twelve year [illegible] rainy season when it separates most [illegible] stems is dried usually by the heat of the sun. The pieces of bark are put into trays consisting of framed hurdles about 1 metre by 2 metres, and provision is made for sheltering them from rain and from dew at night. Sometimes the trays are provided with hinged covers of corrugated iron which can be closed over them to form a sloping roof and in other cases the trays are supported on five or six stages attached to a shed with a corrugated iron roof and having a length equal to that of about fifteen trays. The stages project beyond the shed to distances increasing from above downwards by the length of one tray, and the trays, which are provided with small wheels running on rails, can be moved out from the shed along the stages, so that all are fully exposed to the sun and are run back under cover when necessary. Drying by artificial heat is used on some plantations and sometimes artificial heat is used to complete the drying which had been commenced by the heat of the sun. During the drying, the inner surface of the bark, which is at first quite pale, changes to a brown or red colour, owing to changes taking place in the tannin when exposed to the action of the air. In Java the bark intended for factory use is stamped into sacks and thereby reduced to coarse powder, but quills intended for use by pharmacists are cut into standard lengths and carefully packed in cases.

Description. *General Characters.* Although there are several varieties of cinchona, certain features are common to them all. They vary in colour of the inner surface and of the fracture from tawny yellow to brownish-red and the inner surface is longitudinally striated. Externally they are more or less rough and of a greyish colour; the fracture is short in the cork and cortex and shortly fibrous in the phloem. The taste is bitter and more or less astringent. If the bark in coarse powder is treated with lime and extracted with alcohol, the alcoholic extract evaporated and the residue taken up with dilute acid, the liquid will give a white precipitate with Mayer's reagent and, after neutralisation, a green colour with the thalleioquin reaction.

Typical specimens of bark from the different species of *Cinchona* show well-marked characters by which they are readily identified, but barks from hybrid trees, large quantities of which are now sold, show combinations of characters, although in some instances, such as Ledger bark, the characters of one parent species predominate.

1. *C. Calisaya.* Calisaya bark is one of the varieties known as "yellow" bark, a term which is applied to all cinchona barks exhibiting a distinctly yellowish brown colour. It occurs in two forms, viz.

[illegible] ry [illegible] n. [illegible] se fibrous structure, the undulating course of the fibres often giving a wavy appearance to the bark. The outer surface is darker and marked with broad, shallow, longitudinal depressions, known as digital furrows. These are caused by the exfoliation and removal of pieces of the rhytidoma.

(*b*) *Quill calisaya.* This variety is principally obtained from

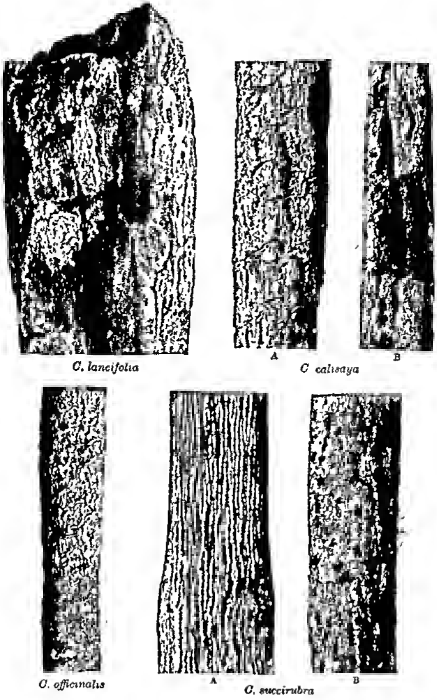


FIG 21. Barks of four species of *Cinchona* All natural size. *C lancifolia*, showing patches of silvery cork. *C. calisaya*, *A*, showing longitudinal furrows and transverse cracks; *B*, showing exfoliating outer bark. *C. officinalis*, showing very numerous cracks with recurved edges *C succirubra*, *A*, showing longitudinal wrinkles, *B*, showing red warts and transverse cracks. (All after Greenish.)

plantations of *C. Calisaya* in Java. It occurs in quills about 12 to 25 mm. in diameter and 30 cm. or more in length, fine specimens attaining 60 cm. in length and 5 to 8 cm. in diameter. The outer surface is of a dull dark grey or dull brown marked with lighter, whitish patches; it is rugged, and exhibits shallow, rather broad longitudinal furrows that are frequently brownish, and hence, even if not deep, are easily seen. Transverse cracks, often across the entire width of the quill, occur at distances of about 6 to 12 mm. This layer frequently exfoliates in patches, disclosing the dull yellowish-brown cortex, which bears impressions corresponding to the cracks of the periderm. The fracture is shortly fibrous; the section exhibits a narrow dark brown cork and brown cortex and phloem. The taste is distinctly bitter and slightly astringent.

2. *C. Ledgeriana*. This species yields a bark that very closely resembles quill calisaya and is remarkable for its richness in quinine, for which reason the tree is being extensively cultivated in Java and also in India; most of the "yellow" bark of commerce is Ledger bark, imported from Java.

The transverse cracks of the outer surface are usually more numerous and less conspicuous than in quill calisaya; hence the bark is rougher than quill calisaya. Some pieces bear distinct longitudinal ridges and scattered reddish warts that recall typical red bark (see below), but from this bark they are easily distinguished by their colour and by their taste, which is bitter but not markedly astringent. Sometimes the cork shows a tendency to exfoliate as it does in quill calisaya.

Large quantities of both calisaya and Ledger barks for factory purposes are imported in coarse powder and can be recognised chiefly by the tawny yellow colour, the bitter and only slightly astringent taste and the shortly fibrous fracture. The two varieties, when in this condition, cannot be certainly distinguished.

3. *C. officinalis*. The bark of this species, commercially known as *pale* or *crown cinchona bark*, is obtained chiefly from India, although some is imported from South America. It occurs in single or double quills only, and these are much narrower than those of calisaya, seldom exceeding 12 mm. in diameter, the bark itself being usually less than 1·5 mm. thick. The outer surface is of a dull brown colour, and often has foliaceous lichens adhering to it. Typical pieces are marked with numerous small transverse cracks often less than 6 mm. apart, in addition to which there are numerous less prominent longitudinal cracks, all of which, but especially the transverse, have thickened and recurved edges, which impart to the bark a roughness to the touch that is characteristic. The colour of the inner surface is usually yellowish-brown, and the taste is bitter and slightly astringent.

4. *C. succirubra*. Succirubra bark is characterised by a more or less distinct reddish colour, and is therefore usually known as "red bark"; it occurs in "flats" and "quills." The former are occasionally imported from South America; the latter are obtained from cultivated trees, principally in Java.

(*a*) *Flat red bark* occurs in flattish pieces, often of considerable size, and attaining 20 mm. in thickness, though usually thinner; in these respects it resembles flat calisaya, but it differs from that bark in

frequently having the outer part attached, the latter is rugged, of a dusky, ferruginous-red colour, and marked with longitudinal ridges of cork as well as brighter red warts The inner surface has also a brick-red colour, and does not exhibit the wavy fibrous structure characteristic of flat calisaya. The bark has a bitter and markedly astringent taste

(*b*) *Quill red bark.* The quills vary in size, but are often about

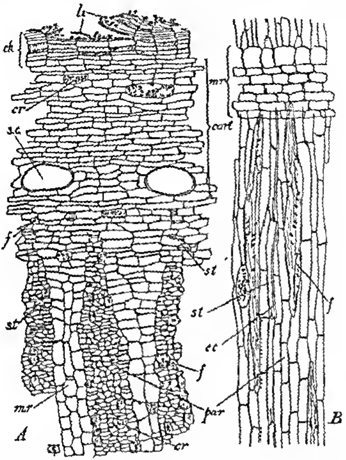


FIG 22 Bark of *Cinchona succirubra* *A*, transverse section, *B*, radial longitudinal section, both × 75 *c c*, companion cell, *ck*, cork, *cort*, cortex; *cr*, microcrystals of calcium oxalate; *f*, fibre, *m r*, medullary ray, *par*, phloem parenchyma; *s c.*, secretion canal, *s t*, sieve-tube

25 mm. in diameter. The outer surface is dull brownish-grey or reddish-brown and often bears numerous greyish lichens, it is wrinkled longitudinally, the older pieces being marked with warts which are sometimes small and numerous or sometimes large and scattered; in the latter case they are either reddish in colour or exhibit a reddish colour when broken Some pieces of the bark bear small transverse cracks and reddish warts, the longitudinal wrinkles being less pronounced; the cracks have clean edges which are not thickened. In thickness the bark varies from 2 to 4 mm. The colour of the inner

surface of typical specimens is brownish-red, but that of the interior of the bark is yellowish-brown. The red colour is due to a change in the tannin of the bark, by which a reddish phlobaphene is produced. *Branch bark* may generally be distinguished from trunk bark by being thinner, by bearing more numerous wrinkles and small warts, and by [illegible] The bark has a taste which is bitter and [illegible] than that of pale or yellow bark.

[illegible] nchona barks yielded by *C. lancifolia* (Columbian, Cartagena barks) occur [illegible] pieces; they are usually more or [illegible] brown in colour. They are easil[illegible] patches of silvery cork which are to be found on almost every piece. The bark has an astringent bitterish taste.

6. *Root bark* is characterised by occurring in rather small curved or channelled pieces, somewhat irregular in shape. Lichens are absent and the outer surface is marked by conchoidal depressions, where the rhytidoma and cork have exfoliated. The colour of the outer and inner surfaces is similar and resembles the colour of the inner surface of the corresponding stem and branch barks.

Histology. The histology of the stem-barks of all the cinchonas is closely similar and a description of the stem-bark of *C. succirubra* will serve as a type. The *transversely-cut surface* of succirubra branch-bark shows externally a layer of cork, then a narrow cortex limited internally by a row of rather distant secretion tubes (tannin-tubes). The remainder and by far the greater part of the bark consists of phloem, across which run numerous medullary rays; in the phloem can be seen the cut ends of the abundant rather large phloem fibres. See Fig. 22.

The *cork* consists of numerous layers of thin-walled, flat, polygonal prisms, filled with reddish-brown masses. The cells of the thin-walled cellulose parenchyma of the *cortex* have red-brown walls and contain small rounded starch grains about 2 to 6 to 10 to 15µ in diameter; occasional cells are filled with micro-crystals—mostly prisms about 2 to 6µ long or Y-shaped groups—of calcium oxalate; near the inner [illegible]

30 to 60 to 95µ wide and 500 to 800 to 1,350µ long, they are mostly solitary, occasionally in short radial rows of two to four fibres. The sieve-tubes have the end walls at right angles to the axis, the component cells being about 200µ long and 15 to 20µ wide and having narrow companion-cells; most of the sieve-tubes are compressed and collapsed. The phloem parenchyma consists of cells with thin, dark reddish-brown walls; some of the cells are filled with micro-prisms of calcium oxalate. The *medullary rays* are from one- to three-seriate. Sclereids are absent, a feature which distinguishes cinchona from cuprea bark, derived from *Remijia pedunculata* and *R. Purdieana*, which contains sclereids. *C. lancifolia* bark also contains sclereids.

Attempts have been made to distinguish the different species of *Cinchona* by the dimensions of the phloem fibres, but conclusions based on these measurements must be received with caution.

Constituents. About thirty alkaloids have been reported as occurring in cinchona barks; many of these are crystalline, but some are

amorphous and it is questionable whether some of them are really present in the bark or may have been produced from other alkaloids during the process of extraction The four most important alkaloids are quinine, cinchonidine, cinchonine and quinidine; those next in importance are hydroquinine, hydrocinchonidine, quiniamine, cinchotine and homocinchonidine. The alkaloids are combined with a tannin, named cinchotannic acid, and are located, according to de Vrij, chiefly in the parenchymatous tissues. Other constituents are a bitter amorphous glycoside, quinovin; a crystalline acid, quinic or kinic acid; starch and calcium oxalate.

The amount of **total alkaloid** present in cinchona barks is subject to great variation. Quilled red bark from India averages about 6·5 per cent.; that from Java is richer, yielding about 8 25 per cent. Calisaya quills afford about 6 or 7 per cent. and pale bark about 6 per cent. Ledger bark from Java is the richest of all, yielding from 5 to 10 per cent. or even more of total alkaloid. Root-bark is the richest, and stem-bark is richer than branch-bark. The relative value of a bark is, however, usually determined by the proportion of quinine it contains, but bark in handsome quills realises a price not altogether consistent with the amount of quinine it contains.

Quinine was first isolated by Pelletier and Caventou in 1820, after Gomez in 1811 had produced from cinchona a crystalline combination of quinine and cinchonine It occurs in the largest proportion in Ledger bark, the highest recorded yield being 14 5 per cent. This, however, is quite exceptional, the quinine in commercial Ledger bark averaging from 3·0 to 8·0 per cent. Bolivian cultivated calisaya contains from 3 0 to 4·0, and cultivated pale bark about 3 0 per cent. Indian red bark contains about 1·5 per cent. of quinine, but that from Java is richer, attaining as much as 5 per cent.

Cinchonine is found in small quantity in most of the cinchona barks, especially that of *C. lancifolia*; it is frequently more abundant in the root-bark than in the stem-bark.

Quinidine, discovered by Henry and Delondre in 1833, seldom exceeds 0·5 per cent. in any bark; it occurs chiefly in certain varieties of *C. Calisaya* and in the root-bark of *C. succirubra*.

Cinchonidine, isolated in 1847 by Winckler, is found more generally distributed and in larger proportion than quinidine. The cultivated red bark exported from India contains as a rule more cinchonidine than quinine, from 3 to 4 per cent. being frequently present.

Cinchotannic acid is a phlobatannin and by oxidation it rapidly yields a dark-coloured phlobaphene, known as cinchona-red.

Quinetum is a mixture of the crystallisable alkaloids of cinchona and has been defined by the Malaria Commission of the League of Nations, 1931, as a mixture of equal parts of quinine, cinchonidine and cinchonine. **Cinchona Febrifuge** is the residue of alkaloids left after removal of the bulk of the quinine from the total alkaloids of these barks used for the manufacture of quinine sulphate **Totaquina** is defined as a mixture of alkaloids from the bark of *C. succirubra, C. robusta* and other suitable species of *Cinchona* and it must contain not less than 70 per cent. of crystallisable cinchona alkaloids, of which not less than one-fifth is quinine

Uses. The cinchona barks are given chiefly as bitter stomachics and tonics The amount of tannin contained in them indicates their use when an astringent effect also is desired.

Substitutes. *Cuprea Bark*, the bark of *Remijia pedunculata*

Triana, and *R. Purdieana* Triana, family Rubiaceæ, from Columbia; coppery red, dense, very hard with a granular and splintery fracture; contains quinine, cupreine, quinidine, cinchonine, and cinchonamine; not now in commerce.

Various species of *Cascarilla*, *Exostemma* and *Stenostoma*; these barks contain none of the cinchona alkaloids.

WITCH-HAZEL BARK. Cortex Hamamelidis

Sources. The witch hazel, *Hamamelis virginiana* Linn., family Hamamelidaceæ, is a common shrub in the United States and Canada. It attains a height of about 3 metres and resembles the common hazel both in its leaves and in yielding an edible seed. The bark should be collected in the spring.

Description. Witch-hazel bark occurs in thin channelled pieces of a pinkish-brown colour, occasionally as much as 15 or 20 cm. long and 2·5 cm. wide, but usually much smaller. They are sometimes covered with an ash-grey smooth cork which in older pieces becomes darker in colour, fissured, and scaly. The inner surface is pale reddish-pink in colour and finely striated longitudinally; small portions of white wood, which are seen in transverse section to be dense and traversed by numerous thin medullary rays, are frequently found adhering to it. The fracture is short in the cork and cortex, but fibrous and laminated in the phloem, due to its containing numerous tangentially elongated groups of phloem fibres. The smoothed transversely cut surface shows a dark narrow cortex and a pale tangential line of pericyclic scleroids separating this from the phloem. In many of the pieces the cork and much of the cortex have been removed, and the ring of sclereids may then form a nearly smooth outer layer. Odour none; taste astringent and slightly bitter.

Histology. The *cork* is thin walled; *the cortex* consists of cellulosic parenchyma containing a few small starch grains and an occasional cell with a prism of calcium oxalate. The *pericycle* forms a band five or six cells wide of evenly thickened scleroids with small groups of pericyclic fibres at intervals on its outer margin. The *phloem* contains tangential bands of lignified phloem fibres having a crystal-sheath with prisms of calcium oxalate, the phloem parenchyma is arranged on the inner and outer sides of the tangential bands of sieve-tubes, the whole alternating with the bands of phloem fibres; groups of scleroids are present in the outer part of the phloem. The *medullary rays* are uniseriate.

Constituents. The bark contains about 6 per cent. of tannin, part of which, hamamelitannin, is crystalline and part amorphous; gallic acid is also present (Gruttner, 1898).

Uses. It is astringent and hæmostatic, and is used in hæmorrhages from the nose, lungs, rectum, or uterus.

QUILLAIA BARK. Panama Wood, Soap Bark, Cortex Quillaiæ, Quillaia

Sources and History. Quillaia bark, or soap bark, is obtained from *Quillāja Saponāria* Molina, family Rosaceæ, a large tree indigenous to Chili and Peru and from other species of *Quillaia*. The bark, which is called "cullay" by the natives and has apparently been long used by them for washing silk and wool, was known to Europeans in the early part of the eighteenth century, but was not regularly imported until about 1857, when it was sent to France under the name of "Bois de Panama," the name indicating the route by which it was sent. It

size.

The outer surface is pale brownish- or yellowish-white, longitudinally striated and streaked with reddish-brown where the rhytidome has been imperfectly removed. Sometimes, from insufficient trimming, the bark is of a uniform dark dull red colour and bears patches of the rhytidome still adhering to it. The inner surface is smooth, white or yellowish-white and very hard.

The fracture is splintery and the fractured surface separates into thin plates or laminæ. On the freshly fractured laminated surfaces and also on the smooth inner surface of the bark, minute, glittering points (crystals of calcium oxalate) can be seen, sometimes in considerable number, with the naked eye, or better with a lens.

The transverse section is traversed by tangential and radial lines, which give it a [illegible]
bands of phloem [illegible]
rays, the darker [illegible]

prolonged fits of sneezing; the taste is acrid and unpleasant.

Other Quillaia Barks. A quillaia bark differing from the foregoing in being thinner and in having a distinctly reticulated outer layer is imported; its botanical origin is said to be *Q. Poeppigii* Walp. Another variety in quills 7 to 15 cm. long, 1 to 2·5 cm. wide and about 3 mm. thick, softer and not laminated, has been referred to *Q. Smegmadermos* de Candolle.

[illegible] phloem, [illegible] phloem [illegible] each of [illegible] ls. The *secondary phloem* consists of tangential bands of sieve-tubes and parenchyma alternating with bands of phloem fibres, from eight to fifteen fibres wide. The sieve-tubes are 20 to 30μ wide and have companion cells; their transverse walls are oblique with several sieve-areas and there are some sieve-areas also on the radial walls. The fibres are often characteristically knotted and bent and sometimes forked at the end; they are lignified and are 20 to 50μ wide and 500 to 1,000μ long. The phloem [illegible]

present, or five or six smaller prisms in a single cell or a cell may be filled with micro-crystals. Very occasional scleroids occur amongst the fibres or [illegible] to 4-seriate [illegible] oxalate are [illegible] up of fibres. [illegible] thin-walled cells.

Constituents. The principal constituents of quillaia bark are two colourless, amorphous, toxic glycosides, quillajic acid and quillaia-sapotoxin. Both of these substances impart to water the property of frothing, and possess other characters common to the class of substances known as "*saponins.*" The drug also contains sucrose, starch and calcium oxalate.

Commercial saponin is usually obtained from quillaia bark, and is a mixture of quillajic acid, quillaia-sapotoxin, and frequently also a non-toxic modification of quillajic acid produced during the preparation; as the term saponin has become a generic one, a prefix to indicate the source would be desirable.

Quillajic acid, $C_{19}H_{30}O_{10}$, has been obtained as a colourless amorphous powder which is strongly sternutatory. The aqueous solution is acid and has an acrid taste. Boiled with a mineral acid it yields quillaia-sapogenin, galactose, and another sugar, which is non-fermentable and dextrorotatory.

Quillaia-sapotoxin, $C_{17}H_{26}O_{10}$, is also white, amorphous, sternutatory, and acrid.

Uses. Quillaia bark has been recommended as a stimulant and expectorant, but has not met with much favour. A tincture is often used as a means of emulsifying tars, etc.

GALLS. Galla, Blue Galls, Aleppo Galls

Sources, etc. Galls are pathological outgrowths formed on the twigs of the Dyer's oak, *Quercus infectoria* Olivier, family Fagaceæ. These excrescences arise in consequence of the deposition of an egg by a small hymenopterous insect, *Cynips gallæ-tinctoriæ* Hartig, family Cynipidæ, often known as the gall-wasp.

On emerging from the egg, the grub pierces the delicate epidermis near the growing-point of the twig, where the egg was deposited, and a secretion from its jaws stimulates a rapid growth of tissue which quickly envelops the grub and forms a spherical excrescence. If the egg fails to hatch, no gall is produced and if the larva dies, the growth of the gall ceases. The grub develops at the centre of the gall, changes into a pupa and finally the imago, or perfect insect, emerges from the pupa and bores a tunnel about 2 to 2·5 mm. in diameter to the outside of the gall and escapes as a small four-winged flying insect. The eggs are laid in spring or early summer and the insect escapes after five to six months.

These galls are collected, before the escape of the insect, in Asiatic Turkey in August and September and are exported from Aleppo; they are therefore commonly known as Turkey, Aleppo or Levant galls.

Description. Galls are sub-spherical and about 12 to 20 mm. in diameter. Externally they are bluish-green or olive-green in colour—hence the name *blue galls*—and are pale buff coloured within. The central region, about 5 to 7 mm. in diameter, is separated from the outer part by a layer of sclerenchyma. Within the sclerenchyma the cells contain proteins and abundant starch, upon which the larva feeds until it enters upon the resting stage and becomes a pupa. At the centre of the gall one may therefore find the insect as either larva, pupa or imago. The imago, which is about 5·0 mm. long and has four membranous wings, is sometimes found just beneath the outer

urface in the end of the tunnel it has bored. The outer part of the gall is about 5 5 to 6 mm. wide and consists of parenchyma containing tannin. Galls are hard and sink in water, which they readily absorb, becoming enlarged and softened. On the surface especially of the apical hemisphere there are about ten to fifteen small bluntly conical projections, the basal half is often smooth. The average weight of a gall is about 3·8 g. with a range of from 1·8 to 4·2 g. Galls have no odour, they have an astringent taste, followed by a sensation of sweetness

Histology. The epidermis ruptures early and is replaced by a *metaderm* composed of one or two layers of suberised cells; the region outside the sclerenchyma is composed of numerous *layers of parenchyma*, the cells of the outermost being smaller and containing chloroplasts; the cells of the middle and inner layers are larger, being also somewhat radially elongated towards the sclerenchyma. The cellulosic walls have large oval simple pits and most of the cells contain several thin irregular transparent *plates of tannin*; other cells, often in radial rows, contain either prisms or cluster crystals of calcium oxalate. Occasional small vascular strands are present. The *sclerenchyma* consists of three to five layers of lignified sclereids without intercellular spaces and occasionally containing cluster crystals of calcium oxalate. The *inner parenchyma* within the sclereids contains starch grains about 15 to 20μ in diameter, a little fixed oil and brown globular or concretionary masses which give a red colour with phloroglucin and hydrochloric acid and are known as *lignin bodies*. At the centre is the insect in one of the three later stages of its metamorphosis.

Constituents. Galls contain as principal constituent from 50 to 70 per cent of tannin, which yields gallotannic acid. They contain also a little gallic acid (2 to 4 per cent.), ellagic acid, cyclogallipharic acid, sugar and starch

Gallotannic acid, the "tannic acid" of commerce, is a pale yellow, amorphous substance yielding bluish-black precipitates with solutions of ferric salts Its aqueous solution darkens when exposed to the air with simultaneous formation of gallic acid, $C_7H_6O_5,H_2O$ and sometimes also of ellagic acid, $C_{14}H_6O_8,2H_2O$.

Uses. Galls are used medicinally as a local astringent chiefly in the form of a suppository or ointment. They find an extensive application technically in tanning and dyeing, in the manufacture of ink, etc.

Other Galls. *White galls* are the galls collected after the escape of the gall-wasp; they are rather larger than the "blue" galls, lighter in weight, and yellowish in colour. They are less esteemed, and are considered to contain less gallotannic acid, which, however, does not from analyses appear always to be the case.

Morean galls or *Crown galls* are formed by *Cynips mореæ* Graffe on *Quercus cerris* Linn and come from Aleppo. They are small, being up to 1 cm. long, somewhat urn-shaped with a short stalk and a crown of projections in the upper part. They contain about 30 per cent. of gallotannin.

Chinese and *Japanese galls* are produced by *Aphis chinensis* Bell, on the petiole of the leaf of *Rhus semialata* Murray, family Anacardiaceæ, taking the place of a leaflet. The aphis is female and several generations of females follow. After the gall has fallen wingless males and winged females

are produced, the latter flying away, after impregnation. The galls are of a very irregularly lobed shape, reddish-brown in colour, hollow and covered with a thick, grey, velvety down; each contains the dried bodies of numerous aphides. They are largely used in the manufacture of gallotannic acid, of which they contain about 70 per cent.

Hungarian galls are produced by *C. lignicola* on *Q. Robur* Linn.; *Bussorah galls* by *C. insana* on *Q. infectoria* Olivier.

CHAPTER VIII

LEAVES

LEAVES are appendages to the stem, which show a great variety of external form and this fact makes it difficult to formulate a definition which is applicable to all leaves. There are, however, two features which are constant, viz., leaves possess neither nodes nor internodes and branches arise in their axils. In the great majority of plants, leaves may be recognised, in addition, by four well-marked characters: (1) Their flattened form, (2) their thinness, (3) the presence of chlorophyll, (4) the presence of supporting and conducting strands—the veins.

The expanded blade or lamina is not always the whole of the leaf; frequently the blade is attached to the stem by a stalk—the petiole; ... commerce are ... ndi and senna ... searching for specimens attached to an axis and a few of these can usually be found. Having found an axis, two points are to be noted; first examine the angle, known as the axil, between the leaf and the axis, where a bud or branch is present in the case of a leaf, but is absent when the structure is a leaflet. Secondly, note the arrangement of the laminæ and the planes in which they lie. If the plant-members in question are leaflets, they are attached in pairs and their laminæ all lie in one plane, whereas in the case of leaves, the arrangement is spiral and the laminæ are in different planes. Another feature of leaflets is that the blade is nearly always unsymmetrical, unless there is a terminal leaflet, which is symmetrical. If senna is examined two kinds of leaflets in equal numbers will be found, one type having the left-hand portion of the lamina smaller and the other having the right-hand portion smaller, this condition indicates a pari-pinnate leaf. Jaborandi consists of two types of asymmetric leaflet in equal numbers and a third type of leaflet which is symmetrical and is present in a smaller number, this condition indicates an imparipinnate leaf and the number of symmetrical leaflets in the sample is the number of leaves present. ... which have ... flowers are ...

... leaves collected in wet weather deteriorate in quality and are apt to become discoloured during drying.

The time of collection is sometimes varied for special reasons, for

example, for the more highly prized varieties of tea, the leaves are collected when still unfolded in the bud; cherrylaurel leaves are gathered while still young, but fully formed and in the first year of their duration; coca leaves are collected when they are nearly ready to fall from the stem; bearberry leaves may be collected at any time of the year, the time chosen being usually September or October.

The method of collection differs widely for different drugs. In [illegible]
leaves are removed individually from the plant; in collecting senna, the entire plants are cut down and the leaves are picked off after drying the plants in the sun; in the case of buchu, the leafy stems are cut off and dried, after which the leaves are removed by beating the heaped twigs with a flexible rod; belladonna, hyoscyamus and stramonium are collected by cutting down the flowering tops and drying the leaves on the stems with the flowers and young fruits without further treatment. As a result of the variations in treatment during collection and also to some extent during packing, the condition in which leaves occur as drugs varies considerably and is often characteristic, thus they may be fresh as for cherrylaurel or they may be dry and whole or broken or shrivelled or flat or matted, etc.

Leaves must be dried carefully so as to retain their fresh green colour and prevent the decomposition of the active constituents. The important factors are to use as low a temperature as possible and to carry out the operation as rapidly as possible. Drying out of doors is hardly ever possible in Britain, but in tropical and sub-tropical countries such a method is practicable and is commonly used for drying senna, a leaf which is not injured by direct exposure to the light and heat of the sun. Ordinarily leaves should be protected from direct sunlight and be taken under cover at night; an indigenous leaf commonly dried in the open is bearberry. Drying in sheds at the air temperature is frequently adopted, especially for leaves containing essential oil. Buchu leaves, for example, are dried by spreading the leafy twigs in a thick layer on the floors of sheds with corrugated iron roofs. Hamamelis leaves are usually spread on trays stacked upon supports about 10 in. apart in small sheds about 5 ft. high and having sloping roofs of corrugated iron, the sides being open to allow a free passage of air. An attic or loft over a barn is frequently used for drying leaves such as peppermint, spearmint, thyme, sage and similar herbs, which are tied in bundles by their lower stalks and suspended from the beams so that the air moving freely through the loft dries off the moisture with a minimum loss of volatile oil. Belladonna is sometimes dried in a similar way, but it is better to use artificial heat for this and similar drugs. Drying in specially constructed heated sheds or drying chambers is now one of the common methods of drying leaves. The great advantage of this method is that the producer has complete control of the conditions and is unhampered by difficulties arising from changes in the weather. For this purpose a shed is constructed with openings in the upper part of the walls or in the roof for the exit of the moist warm air and inlets for fresh air near the

floor, adjacent to which the heating apparatus is placed. Heat is supplied either by stoves or more commonly by hot-water pipes. Within such a shed a staging is constructed of wooden uprights having shelves of coarse wire netting spaced about 10 to 12 in. apart in a vertical direction; upon these, the leaves are placed on pieces of canvas, which can be removed as the leaves become dry and replaced by others with fresh leaves. In other cases the staging is arranged to take trays about 3 ft. by 2 ft. having a wire-netting base; the leaves are spread, preferably in a single layer lower surface uppermost, upon canvas sheets laid upon the wire netting. Between the stages of shelves, gangways are provided along which the attendant can pass to remove and replace the leaves. As the leaves become dry, they are moved downwards on to the lower stages and fresh leaves are placed

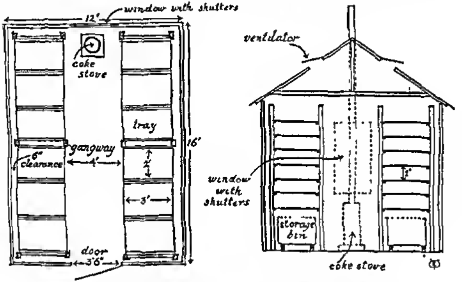
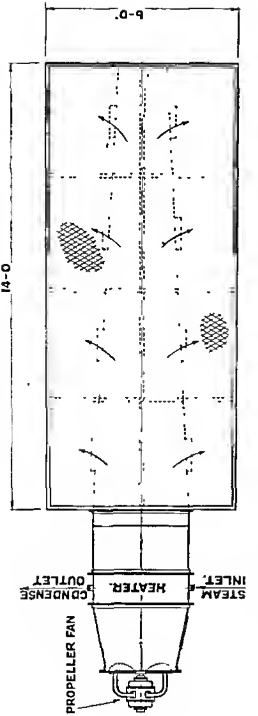


FIG 23. A simple form of drying shed heated by a coke stove.

upon the uppermost stage, so that the moisture given off from the fresh leaves may not dampen the already partially dried leaves; see Fig. 23.

Other arrangements consist of chambers into which a large stand with shelves for the leaves can be run on wheels moving on rails and heated air is either drawn or forced over the shelves from back to front of the chamber by means of a fan and drying is quickly effected, see Fig. 25 The temperature used is about 50° to 60° C (120° to 140° F.). Some drug firms use vacuum ovens for drying leaves such as digitalis which are very rapidly and efficiently dried by this means.

Leaves are most commonly packed in sacks or bales; buchu and Alexandrian senna are packed loose, without pressing, in sacks; Indian senna is packed in bales and subjected to hydraulic pressure, giving very hard, large rectangular packages about 6 ft. long and 3 ft. square at the ends. Coca and tea are usually packed in lead-lined wooden cases, slight pressure being used. Storage of dried leaves should be in a cool dry place, protected from the light; before packing



PLAN.

FIG. 24. "Table" drier made by the Sturtevant Engineering Co. Ltd. The material to be dried is spread upon the wire-netting "table." Air, warmed by being driven through a steam-heated chamber, is conveyed beneath the netting in a tapering tube, from the sides of which it escapes through openings and rises to pass through the netting and the drug spread upon it.

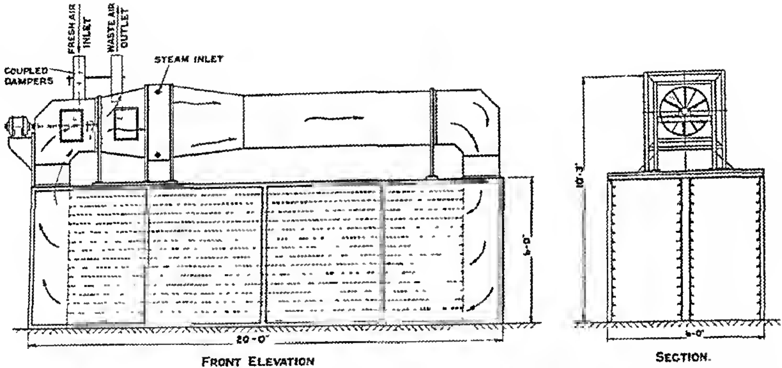


FIG 25. Tunnel drier, made by Sturtevant Engineering Co. Ltd. Material to be dried is placed on netting trays which are placed upon the two sets of supports shown in the section. *These trays are pushed forward by other trays, as they are loaded,* until the tunnel is filled. After closing the doors, heated air from the large tube above is circulated through the tunnel until the drug is dry. The operation takes about eighteen hours.

they are commonly stored loose in barrels or sacks in the drying rooms. Storage conditions applicable in particular cases are discussed under the individual leaves.

Histology of Leaves. Leaves being developed as outgrowths from the stem possess the same three tissue systems as are found in stems, namely, the epidermal, cortical and stelar systems. The epidermis, in its general features, resembles that of other members of the plant; the cortical

of the stem and is the tissue derived from the dermatogen of the growing point. Usually it consists of a single layer of cells, but may become many-layered as a result of periclinal division; such many-layered epidermises are seen in *Piper Betle* (Betel leaf), *Piper angustifolium* (Matico) and *Ficus elastica* (Indian rubber plant). A many-layered epidermis often acts as water storage tissue as in *Piper Betle* and the inner layer is often described as a hypodermis, although a true **hypodermis** is formed from the cortical tissue—the mesophyll—and not from the

ypes of hypodermis cannot be

podermis may be conveniently

abular or lenticular and show

, except where the pores of the

stomata occur. The anticlinal walls are often straight as in senna and

length and breadth; in many monocotyledons, which have long, narrow leaves, the cells are axially elongated and in grasses dwarf cells alternate with others which are many times their length. More rarely groups of smaller cells occur here and there in an epidermis as in *Piper Betle.* The outer walls of epidermal cells are usually differentiated into layers; externally is a layer which reacts to the stains for fats and is quite impervious to water; this is the cuticle. Within the cuticle the wall is composed of cellulose and when the wall is of considerable thickness, striæ are often visible in its substance. The **cuticle** of *Agave* has been chemically examined (Lee and Wheeler, 1925) and shown to contain (1) water-soluble material 10 per cent., (2) waxy material soluble in alcohol, benzene and chloroform 15 per cent., (3) cellulose soluble in cuprammonia 14 per cent., and (4) a residue—cutin—60 per cent. This purified **cutin** is the characteristic constituent of cuticle; it is regarded (Priestley, 1921) as an aggregate of modified—condensed or oxygenated—forms of fatty acids, known as the cutinogenic acids. After having diffused along the walls of the underlying tissues, these fatty acids appear on the outer surface of the epidermis and there undergo changes into cutin. Four acids, two semi-liquid and two solid, have been isolated from cutin by saponifying it with alcoholic caustic potash and these acids are closely similar to those obtained from the suberin of cork. Cuticle responds to the tests which have been enumerated for cork (see p. 65). Cuticle is frequently thrown into slight ridges on its outer surface and so gives rise to the appearance of striations upon the epidermis when seen in surface view; this is well exemplified in belladonna and in *Ailanthus.* See Fig. 29.

Thickenings also sometimes occur on the anticlinal walls and give important characters to the epidermal cells. For example, *Digitalis lutea* has thickenings on these walls in the angles of the undulations, giving rise in surface view to the appearance of a bead in the apex of each angle.

Digitalis lanata has numerous bars of thickening with long oval pits between them and these are visible in surface view as rows of beads on the walls. *Digitalis purpurea* has no such thickenings and the three leaves can therefore be distinguished by this means.

Epidermal cells are sometimes extended outwards in dome-shaped or somewhat conical projections which are termed **papillæ**, the epidermis being named papillose. This feature occurs most frequently on the under surface as in coca leaves and in dog senna, *Cassia obovata*. A similar feature is more rarely exhibited by cells of the upper epidermis as in the leaves of *Lobelia inflata* and in klip buchu, *Adenandra fragrans*. Seen in surface view papillæ give the appearance of a circle in the centre of the lumen of each cell. See Fig. 34 *F*.

An elongated tubular outgrowth of an epidermal cell is termed a **trichome** or plant-hair; a trichome therefore consists of two parts, the portion embedded in the epidermis and termed the foot, and the free projecting portion named the body. The occurrence and form of trichomes are very valuable anatomical characters for the identification of leaves. They may be **absent** as in the case of such glabrous leaves as rue, savin, coca, hemlock and convallaria, or they may be of **rare** occurrence as in buchu, bearberry, henna and maté. Many leaves possess trichomes in more or less abundance and three types can be recognised; these are: (1) covering trichomes, (2) glandular trichomes, and (3) hydathodes and other special types. In each of these groups there is a wide variety of form.

Covering trichomes may be unicellular or pluricellular. Examples of unicellular covering trichomes are the linear, strongly waved, thick-walled trichomes of yerba santa, *Eriodictyon californicum*; the linear, thick-walled and warty trichomes of damiana, *Turnera diffusa*; the short, conical trichomes of tea and buchu; the short, conical and warty trichomes of senna; the large conical and longitudinally striated trichomes of *Lobelia inflata*. Pluricellular trichomes may be unbranched or branched. Unbranched, uniseriate conical trichomes are found in digitalis, usually three to four cells long, in stramonium, usually three cells long and in belladonna, usually four to five cells long; multiseriate trichomes are found in euphorbia pilulifera and in male fern, where the ramentum is of the nature of a trichome. Branched pluricellular trichomes may be stellate as in hamamelis and althæa leaves; this type is sometimes described as a radiating group of unicellular conical trichomes. A second form is found in the leaf of *Elæagnus*, where the trichome has a short stalk surmounted by a plate-like arrangement of united radiating cells and is termed peltate from its resemblance to a shield. Another kind of trichome consists of a central uniseriate axis, from which side branches arise at the position of the cross-walls between the cells of the axis and is named a candelabra trichome; such trichomes are found in mullein and in the plane tree.

Unicellular **glandular trichomes** are not common; they occur, for example, on the leaves of *Piper Betle* and are termed pearl glands. Similar glands are found on the margins of the ramentum of *Aspidium spinulosum*, the rhizome of which closely resembles that of male fern and may be distinguished by the presence of these glands on the ramenta. Most glandular trichomes are pluricellular, the simplest type having a uniseriate stalk with a single spherical secreting cell at the apex; in *Digitalis purpurea* a few such trichomes have a unicellular stalk, in *Digitalis Thapsi* the stalk is usually three- to four-celled; belladonna leaves also bear similar trichomes. Most glandular trichomes of *D. purpurea* have a unicellular stalk and a bicellular head. In henbane the stalk is uniseriate and the secreting head ovoid and pluricellular. The glandular *trichome* characteristic of the Compositæ has a short biseriate stalk and a biseriate secreting head of about two tiers, as found in the bracts of santonica. In

the Labiatæ the glandular trichome has a short stalk and a secreting head

walls of the cells beneath the cuticle, which is raised to form a delicate bladdery envelope enclosing the oil or oleo-resin.

A leaf bearing trichomes of a **special type** is *Piper Betle*, where some trichomes are developed as hydathodes or organs for the absorption or secretion of water.

Frequently, in dried leaves, many of the trichomes have fallen or been rubbed off, leaving a scar or **cicatrix**, which is usually surrounded by epidermal cells showing a characteristic arrangement, often radiating from the cicatrix; this is well seen in senna and stramonium.

Stomata are another type of epidermal structure possessing great diagnostic value. A stoma consists of two similar cells, the guard-cells, placed

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During the formation of a stoma, the cells cut off from the mother-cell often acquire a shape and size differing from those of the other epidermal cells and are therefore termed the subsidiary cells.

The **appearance of stomata** in transverse sections of leaves varies widely according to the direction in which the section passes through the stoma.

stramonium and belladonna they lie in the same level. These features are illustrated under Savin, p. 267, and Belladonna, p. 282.

Stomata with one or both guard-cells partially or entirely collapsed occur in small numbers in the leaves of stramonium and of belladonna and in considerable numbers in *Datura Metel*. These modified stomata may be described as half stomata and collapsed stomata respectively. Another kind of modified stoma is known as a **water-pore**. These are points of exit for excreted drops of water, which may sometimes hold calcium carbonate in solution. In appearance and structure a water-pore resembles a stoma, but the guard-cells are immovable. They occur upon the teeth of the margin of the leaf and either on the extreme edge between the two surfaces or, more commonly, on the upper surface, and they are placed over the end of a vascular bundle. About ten to twelve such pores are found on each tooth of the margin of the leaves of *Lobelia inflata* and one or very rarely two large pores are present on many of the marginal teeth of *Digitalis purpurea*. Another indigenous plant, sometimes used medicinally, having water pores is *Alchemilla vulgaris*, the Lady's mantle.

Occurrence of Stomata. Stomata are entirely absent from submerged leaves of aquatic plants, such as *Elodea canadensis*, the American water-weed and from the leaves of all Bryophytes. The leaves of ordinary land

plants possess stomata which vary in their distribution. They may be present in exceptional cases on the upper surface only, as in *Ammophila arundinacea*, the Marram grass, and on the floating leaves of plants such as the water-lily. In many coriaceous leaves, such as cherrylaurel, maté, coca and rosemary, they are present on the lower surface only. In a few instances stomata occur in about equal numbers on the upper and lower surfaces as in senna and mistletoe and generally speaking on leaves having the lamina in a vertical instead of the more usual horizontal plane. Lastly, they may be present in fairly large numbers, but more numerous on the lower than the upper surface; this is a condition found in most of the thinner leaves of herbaceous plants, especially shade plants, such as digitalis, stramonium and belladonna. The actual number of stomata per square millimetre is variable for the same plant, this being especially noticeable if records are made for different years; a few examples, however, serve to give an idea of the numbers which have been recorded :—

	Number of stomata per sq. mm.	
	Upper surface	Lower surface
Prunus Laurocerasus . . .	0	140 to 180
Barosma betulina . . .	0	45
Datura Stramonium . . .	59 to 87 to 140	145 to 200 to 254
Atropa Belladonna . . .	7·5 to 10 to 17·5	77·5 to 113 to 176
Cassia angustifolia . . .	180 to 200 to 223	195 to 220 to 257

The **Stomatal Index** (Salisbury, 1927) is the percentage which the number of stomata form of the total number of epidermal cells, each stoma being counted as one cell. Thus, if S represent the number of stomata per unit area and E the number of epidermal cells in the same unit area, the *stomatal index* is $S \times 100 \div (E + S)$. The figure so obtained is fairly constant for any species and can be used as a specific character, which has proved useful for distinguishing leaflets of Indian from those of Alexandrian senna and also leaves of *Atropa belladonna* from those of *A. acuminata*. Recorded values (Rowson, 1943) are as follows :—

Atropa belladonna lower surface . .	10·5 to 21·6 to 23·0
Atropa acuminata lower surface .	16·7 to 17·6 to 18·8
Cassia acutifolia both surfaces	11·4 to 12·2 to 13·0
Cassia angustifolia both surfaces	17·1 to 18·7 to 20·0
Erythroxylum coca lower surface	12·0 to 13·3 to 15·4
Erythroxylum truxillense lower surface	8·4 to 10·1 to 11·5

Orientation of the Stomata. The stomata in gymnosperms and monocotyledons are usually placed with the axis or porus parallel to the long axis of the leaf, as in savin and lily of the valley (*Convallaria*); an exception amongst the gymnosperms is *Ginkgo*, the leaves of which have the stomata placed irregularly. In dicotyledons the orientation is usually irregular. Sometimes it is parallel to the long axis as in many Mimoseae, and is at right angles to the long axis in some other plants, such as *[illegible]* and *[illegible]*.

Types of Stomata. Four types of stoma may be distinguished by the characters of the guard-cells. These are (1) the moss type, which is found in the sporogonium of the theca and when mature possesses guard cells which are united by the breaking down of the dividing wall during growth;

Funaria is a good example. (2) The **gymnospermous** type having guard-cells which are oval in transverse section and are placed at an angle of about 45 degrees with the outer surface and have walls which are in part lignified; a typical example is savin. (3) The **graminaceous** type, which is characteristic of the Gramineæ and Cyperaceæ and has guard-cells which, in surface view, are more or less dumb-bell shaped and the outline sub-rectangular. (4) The **dicotyledonous type**, which is oval or circular in outline in surface view with arcuate guard-cells; this type is found in most dicotyledons and in many monocotyledons.

Amongst dicotyledons four well-marked types of stoma occur; these are distinguished by the form and arrangement of the surrounding cells, more especially of the subsidiary cells as seen in the mature leaf. Each type is named from a family, of which it was first noted as being characteristic; they are as follows: (1) The **ranunculaceous** type, where the stoma is surrounded by a varying number of cells in no way differing from those of the epidermis generally. Such stomata occur in bearberry, buchu, foxglove, hemlock, lobelia and many other leaves. (2) The **rubiaceous** type; the stoma has two subsidiary cells the long axes of which are parallel to that of the stoma. Examples are coca, senna and boldo. (3) The **caryophyllaceous type**; the stoma is accompanied by two subsidiary cells the long axes of which are at right angles to that of the stoma. This type is found in many plants of the family Labiatæ, such as spearmint, peppermint and thyme. (4) The **cruciferous type**; the stoma is surrounded by usually three subsidiary cells, of which one is markedly smaller than the others. Examples are belladonna, stramonium, henbane and many plants of the family Solanaceæ; also *Carthamus* and many pla...

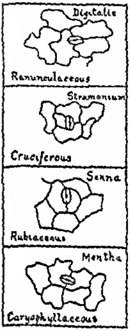

FIG. 26. Types of dicotyledonous stomata. All ×

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to carry out the functions of the leaf. The cells of the mesophyll have

... urrounded by ... examples are ... lat and has a ... dermis. The palisade cells are cylindrical and closely packed with their long axes at right angles to the epidermis. Between the cells there are small spaces parallel to the long axes of the cells; the spaces are not easily seen in transverse sections of leaves, but are immediately evident in surface preparations. Examples of **isobilateral** leaves are eucalyptus, in which there are from three to five rows of palisade under each epidermis, and senna in which there is a single row above and below. The **dorsi-ventral**

leaf is flat and has a distinct upper and under surface; the upper surface is usually darker in colour than the lower. The mesophyll is divided into a palisade layer of one or more **rows of cells** under the upper epidermis, and a loose tissue of irregular cells with short projecting arms enclosing abundant intercellular spaces and known as "spongy" parenchyma.

Idioblasts are cells which *differ markedly from* the ordinary cells of a tissue in either form, size or contents. Such cells are often present in the mesophyll of leaves; in tea and hamamelis peculiarly shaped, thickened and strongly lignified idioblasts occur and are very characteristic of the powder as well as the whole leaf. In laurel leaf, *Laurus nobilis*, in boldo leaves, *Pneumus Boldo*, and many leaves of the Piperaceæ the idioblasts are large spherical cells filled with volatile oil; in belladonna one finds

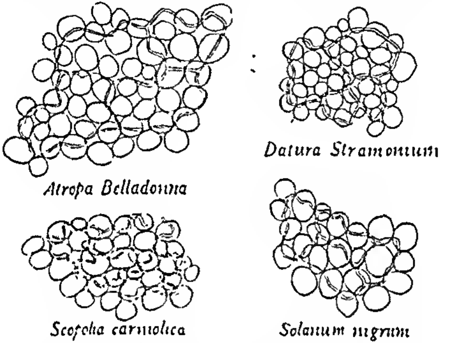

FIG. 27. Palisade ratio. Four epidermal cells from four leaves with the underlying palisade cells, showing the differences in the ratios. All × 175. After Wallis and Forsdike.

large rounded idioblasts filled with microsphenoidal crystals of calcium oxalate. In some leaves, such as stramonium and henbane, the idioblasts containing calcium oxalate are arranged in a single layer immediately below the palisade and constitute a **crystal layer** in the mesophyll. Another peculiarity characteristic of certain leaves, such as those of *Euphorbia hirta*, is the presence of a layer of modified parenchyma immediately surrounding each of the veins; in transverse sections this appears as a sheath of large rectangular cells surrounding each vascular bundle. This sheath gives rise to the peculiar appearance of minute curved rugæ so characteristic of the dried leaves of euphorbia pilulifera (see p. 280).

The palisade cells of the mesophyll bear a definite relation to the epidermal cells, a fact which becomes evident from a study of the **palisade ratio**, which is the average number of palisade cells beneath one epidermal cell, using four contiguous epidermal cells for the count. This ratio has been shown to be sufficiently constant to serve as a diagnostic character of species belonging to the same genus in certain instances, such as the

genus *Barosma* and several genera of the Compositæ. The following examples show the magnitude of ratios that occur and the nature of their variation :—

Barosma betulina	10 to 26
Barosma ovata	5 to 14
Ailanthus glandulosa	7 to 13
Atropa Belladonna	6 to 10
Datura Stramonium } *Datura Tatula* }	4 to 7
Digitalis purpurea	3·7 to 4·2
Xanthium Strumarium	3 to 4
Scopolia carniolica	3 to 5 rarely 6
Solanum nigrum	2 to 4

The mesophyll is divided into small portions by the branching and anastomosis of the veins throughout the tissue. The small areas of green

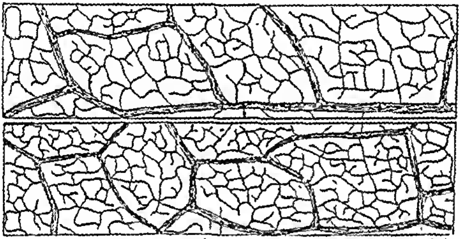

FIG. 28. Vein-islets of *A*, *Cassia angustifolia*, and *B*, *Cassia acutifolia*. × 24. After Levin.

tissue outlined by the veinlets are termed vein-islets and frequently a small vein-tip runs out from the surrounding veinlets into the centre of each islet. The shape of the vein-islets is frequently characteristic and will often enable one to sort out a mixture of leaves which have been broken into small fragments. It has been shown that the number of vein-islets per unit area of leaf surface is constant for any given species of plant and can be used as a character for the identification of species. The **vein-islet number** is the number of vein-islets per square millimetre, and this number is independent of the size of the leaf and does not alter with the age of the plant. The following examples illustrate the value of this character :—

Cassia angustifolia	19 to 23
Cassia acutifolia	25 to 30
Digitalis purpurea	2 to 5·5
Digitalis Thapsi	8·5 to 16
Digitalis lutea	1 to 2
Barosma betulina	10 to 15
Barosma Bathii	15 to 20
Barosma venusta	5 to 7
Erythroxylum coca	8 to 12
Erythroxylum truxillense	15 to 26

Around the veins and midrib the cortical tissues are usually less specialised. In many leaves the palisade is not continued over the veins,

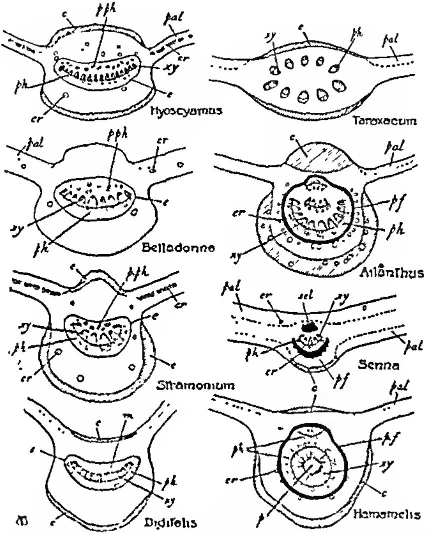

FIG. 29. Transverse sections of midribs of leaves. c, collenchyma; cr, crystal idioblast; e, endodermis; p, pith; pal, palisade; p f, pericyclic fibres; ph, phloem; p ph., perimedullary phloem; xy, xylem.

present to a greater or less extent in the midribs and larger veins of most leaves, forming the layer of mechanical elements which supports the projecting tissue of the midrib and large veins; the remaining cortical tissue of these veins consists of round-celled parenchyma.

Stelar Tissues. The meristele, as seen in a transverse section of the midrib, is usually in the form of an arc having the xylem towards the upper surface, arranged in radiating bands spreading towards the lower surface. The phloem forms a band between the xylem and the cortical parenchyma

on the lower side. Medullary **rays** traverse the xylem and phloem in radiating lines. There is often a small amount of cambiform tissue between the xylem and phloem as is well shown in uva-ursi leaves. The pericycle lying between the phloem and the cortex is sometimes developed as a band of collenchyma as in *Digitalis purpurea* or, more usually, as an arc of pericyclic fibres as in senna. The arc of fibres is sometimes continued some distance round the upper side of the meristele as in coca or is even extended to form a ring completely surrounding the meristele as in *Hamamelis*; in senna there is an arc of pericyclic fibres below the meristele and a small isolated group of fibres on the upper side. See Fig. 29.

Leaves such as belladonna, stramonium and henbane possess small groups of perimedullary phloem embedded in the parenchyma on the upper

nium, the bundles of the meristele are entirely separate, and in leaves like matico, *Piper angustifolium*, and dandelion, *Taraxacum officinale*, the separate bundles form an almost perfect circle as seen in the primary structure of stems, but the bundles towards the upper side are usually smaller than the others. In *Eucalyptus globulus* the meristele of the midrib shows a typical arc of xylem and phloem and above this chief bundle are two smaller bundles in the reverse position, *i.e.*, with the xylem below and the phloem above; in *Hamamelis* also one often finds a small subsidiary bundle above the large principal one; these appearances are produced by the twisting and branching of the bundles which enter the midrib from the stem.

The midrib and its branches gradually become narrower towards their extremities and the conducting elements are reduced in size, till finally all secondary structures are absent. Of the primary structures, the phloem

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ontain protoplasm, cell-sap and a nucleus; in addition chlorophyll is present in plastids in the cells of the palisade and spongy parenchyma. The **chloroplasts** are most abundant in the palisade and numerous very small starch grains, frequently somewhat needle-shaped, often occur embedded in the chloroplasts. The epidermal cells of the fronds of ferns normally contain chloroplasts, but the epidermis of angiospermous leaves is generally without them. Many shade plants, however, such as foxglove, stramonium and belladonna, shew the presence of small numbers of chloroplasts in the epidermis. **Calcium oxalate** is an important cell-content and is sometimes, though rarely, present in the epidermis; good examples are savin, *Cupressus sempervirens* and *Globularia alypum*, sometimes known as Provence senna. In savin and *Cupressus* the crystals are small prisms, about 4 microns long, occurring embedded in the cuticle, about nine or ten crystals to each cell. In *Globularia* many epidermal cells contain a single crystal which is usually a prism, more rarely a cluster. The occurrence of a crystal layer in leaves has been described above (see p. 103). When calcium oxalate occurs in the palisade tissue, it is usually in the form of cluster crystals, as in senna. Idioblasts containing microsphenoidal crystals are found scattered throughout the mesophyll of belladonna. **Calcium carbonate** occurs as a concretionary deposit encrusted upon

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elongated cylindrical-ovoid form occur in the epidermis of *Andrographis*

family Acanthaceæ. **Diosmin**, $C_{24}H_{44}O_{21}2H_2O$, is another crystalline substance occurring in the epidermis of some leaves such as buchu and hemlock. Diosmin occurs in yellowish-grey crystalline masses of various forms and is insoluble in solution of ammonia and in the ordinary microscopical reagents, including solution of chloral hydrate. **Volatile oil** occurs in idioblasts in the leaves of plants belonging to the Lauraceæ, such as *Laurus nobilis*, the bay laurel, and to the Piperaceæ, such as *Piper Betle*.

Classification of Leaves

A. Aromatic leaves with a punctate lamina, usually flat: Buchu, Jaborandi, Eucalyptus, Laurel.

B. Aromatic leaves, lamina not punctate, usually flat: Eriodictyon, Boldo

C Coriaceous leaves, non-aromatic, usually flat: Cherrylaurel, Bearberry, Maté.

D. Lamina thin and papery, mostly flat, often entire, sometimes more or less broken: Coca, Senna.

E. Lamina thin, folded, often broken: Witch-hazel, Henna, Raspberry.

F. Lamina thin, crumpled, broken, twisted by drying, margin toothed: Digitalis.

G Leaves rolled together, somewhat coriaceous: Tea.

H. Leaves destitute of chlorophyll, forming a bulb: Squill, Urginea.

BUCHU LEAVES. Folia Buchu, Bucco, Buchu

Sources. Buchu leaves are obtained from certain species of *Barosma*, small shrubby plants indigenous to Cape Colony. The drug, the use of which appears to have been learnt from the Hottentots, was introduced in 1821, and this first consignment was derived from *B. crenulata*. The leaves of *Barosma betulina* B. & W. are known as round buchu, those of *B. crenulata* Hooker as oval buchu, and those of *B. serratifolia* Willd. as long buchu. The most highly valued variety is round buchu from *B. betulina* B. & W.

Cultivation and Collection. A situation possessing an abundant rainfall and a moist atmosphere is chosen and the soil should have a sunny aspect and a slope sufficient to cause rain to drain off rapidly. The seed is sown in March in lines about 3 ft. apart, and when the plants are a year old they are cut down to about 3 in. from the ground and when two years old are again cut back to 2 in. above the first cut and so on annually. In this way bushy plants with an abundance of twigs are produced. The heavy rains of March and April wash the foliage clean and the twigs are cut with a secateur and are carried on a truck to a shed with a corrugated iron roof, and piled upon the floor to form a layer from 15 to 18 in. deep. The twigs are turned over and shaken loose daily until the leaves begin to fall; they are then gently threshed with a pliable rod two or three days in succession till all the leaves are removed. The whole operation takes from ten to fourteen days. The leaves are sorted from the twigs and are packed into bales, which are turned daily for a week to prevent sweating and subsequent loss of volatile oil. When exported the leaves should not contain more than 10 per cent. of the smaller twigs and most samples contain less than 5 per cent.

Description. The leaves of *Barosma betulina*, commercially known as "short" or "round" buchu, average from 1 to 2 cm. in length, and

are green to pale green in colour; the lamina is rhomboid-obovate in outline, and the apex is strongly recurved and blunt. They are rigid and brittle when quite dry, but cartilaginous when moist. The surface is glabrous or very nearly so, short trichomes being often present on the midrib near the base and on the very short petiole; the upper surface presents small scattered prominences due to the elevation of the epidermis by subjacent oil-glands; the lower surface is finely

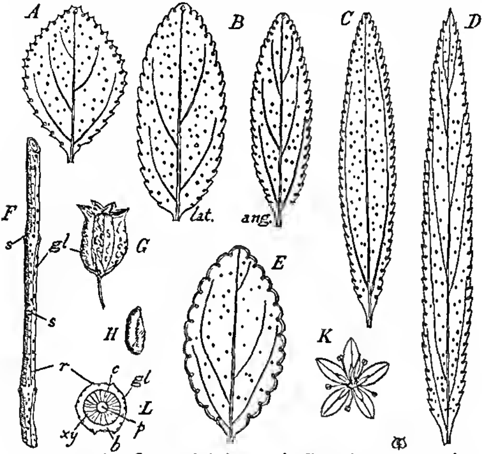

FIG. 30. Buchu. Leaves of *A*, *Barosma betulina*; *B*, *B. crenulata*, *lat.*, var. *latifolia*, *ang*, var. *angustifolia*; *C*, *B. serratifolia*; *D*, *Empleurum serrulatum*; *E*, *B bathii*. All × 2. *F*, stem of *B. betulina* × 1. *G*, fruit of *B. betulina* × 2. *H*, seed of *B. betulina* × 2. *K*, flower of *B. betulina* × 1. *L*, transverse section of stem of *B. betulina* × 5. *b*, bark; *c*, cambium; *gl*, gland; *p*, pith; *r*, ridge; *s*, leaf scar; *xy*, xylem.

wrinkled. The margin is denticulate towards the apex, serrulate towards the base. Examined by transmitted light the lamina is punctate owing to the presence of the scattered oil glands as well as the marginal glands, one of which is situated at the base of each indentation and one in the apex of the lamina. Not infrequently the flowers, the brownish fruits and the black seeds may be found in the drug in addition to small pieces of the stems.

The *slender stems* of buchu are about 2 mm. in diameter and show leaf-scars in opposite and decussate pairs, the internodes being about 8 to 20 mm. long and marked by four longitudinal ridges. The stems are

brownish-red and somewhat rough on the surface owing to the presence of oil-glands in the outer part of the cortex. *In transverse section the stem shows a small lignified pith, a wide xylem and a narrow bark.* The *flowers* are pentamerous and about 12 mm. across the corolla, which has white or pinkish, narrow, acute, lanceolate lobes. The five-valved, capsular *fruits* are about 7 mm. long and 10 mm. wide at the apex, when dehisced; the surface is greenish-brown and rough from the presence of oil-glands; in each loculus there is a single, hard, smooth, oblong-ovoid shining black *seed*, which is non-endospermic.

The leaves have a strong aromatic somewhat peppermint-like odour and a similar taste.

The leaves of *Barosma crenulata* Hooker are known as "oval" buchu. They vary in outline from lanceolate to oval-oblong; the margin is minutely serrate, and the apex blunt but not recurved (as in *B. betulina*). In odour and taste they resemble short buchu There are three varieties of *B. crenulata*, viz., var *latifolia* Berg, var. *longifolia* Berg and var. *angustifolia* Berg. These varieties differ in the length-breadth ratio of the leaves, which are 2 to 3 for var. *latifolia*, 3 to 4 for var. *longifolia* and 3·5 to 5 for var. *angustifolia*.

The leaves of *Barosma serratifolia* Willdenow are known commercially as "long" buchu. They are about 2·5 to 4 cm. long and linear-lanceolate in outline. The margin is serrate, and the apex distinctly truncate. The leaves contain oil-glands similar to those of short buchu, one being distinctly visible in the truncate apex when examined with a lens. In odour and taste they resemble short buchu. There are two varieties of *B serratifolia*, viz., var. *latifolia* B. & W. with a length-breadth ratio of 4 to 6, and var. *longifolia* B. & W. with a length-breadth ratio of 6 to 9. The leaves of both varieties of *B. serratifolia* may be distinguished from those of *B. crenulata* by the marked three-nerved venation which is never found in *B. crenulata*.

Histology. The midrib, which projects below and has a shallow groove above, is about 4 to 5 mm. thick and contains a meristele which exhibits in transverse section an arc of radiate xylem with about six medullary rays, below which is a narrow band of phloem, backed by a crescent of unlignified pericyclic fibres, about six fibres wide at the middle point; above the xylem is a small amount of parenchyma and the palisade tissue is continuous above the bundle; below the bundle are a few layers of parenchyma. The upper epidermis of the leaf consists of polygonal-tabular cells with straight anticlinal walls and possessing a fairly thick cuticle; mucilage fills the lower half of the cells, most of which also contain feathery or sphaero-crystals of diosmin, which is insoluble in ammonia, but is coloured yellow by caustic potash; stomata are absent. The lower epidermis resembles the upper, but contains stomata of the ranunculaceous type and shows, over each oil-gland, a patch of modified thin-walled cells. The leaves of *B. betulina* always possess a number of stomata of a length greater than 38 microns and have a palisade ratio which is never less than 10, features which distinguish them from the leaves of many other species of *Barosma*. In the mesophyll of buchu leaves there are sub-spherical or ovoid schizo-lysigenous glands up to about 250 microns in diameter, and also some cells each containing a cluster crystal of calcium oxalate. The trichomes found on the upper surface of the leaf near the base of the midrib and on the short petiole are unicellular, conical and about 50 to 80 microns long.

Constituents. The principal constituents of buchu leaves are volatile oil and mucilage, the former being contained in the oil-glands, while the latter is deposited on the inner walls of the epidermal cells. They contain in addition a yellow, crystalline rhamno-glycoside diosmin. This substance is also found in *Conium maculatum* Linn., *Mentha crispa* Linn., and many other plants, often forming sphero crystals in the epidermal cells; it closely resembles hesperidin, which occurs in various species of *Citrus*, but differs from it by being insoluble in ammonia. The volatile oil (1·3 to 2 per cent.) deposits up to 30 per cent. of crystalline diosphenol, $C_{10}H_{16}O_2$, when it is cooled. Diosphenol has antiseptic properties, and is considered by some to be the most important constituent of buchu. The oil also contains a ketone, probably identical with menthone, to which the peppermint-like odour is due.

Substitutes. *Empleurum serrulatum* Aiton; resemble long buchu, under which name they have been offered for sale; apex acute without oil gland, colour usually yellowish-green, taste bitterish, odour different.

The leaves of the following plants have also been reported as substitutes for buchu leaves :—

Agathosma cerefolium Bartling and Wendland, *A. microphylla* Meyer, *A. variabilis* Sonder, have a distinct anise colour; *A. chortopila* Ecklon and Zeyher has a cummin odour.

B. Bathii Dummer; rather broader than *B. crenulata*, more distantly crenate-serrate, apex very obtuse and without gland, thickened margin.

B. venusta Ecklon and Zeyher; small, obovate or oblanceolate. They exhibit a strong blue fluorescence in filtered ultra-violet light.

B. pulchella Bartling and Zeyher; 7 to 12 mm. long, 5 to 8 mm. broad, ovate or ovate-lanceolate, margin thickened, apex obtuse; taste different.

B. ericifolia Andr., *B. succulenta* Thunberg; leaves heath-like linear.

B. lanceolata Sonder; rather narrower than *B. crenulata*, margin entire, recurved.

Psoralea obliqua Meyer; lamina oblique, apiculus recurved, veins hairy.

Adenandra fragrans Rœmer and Schultes; oblong, obtuse; caraway odour. Known as Klip Buchu.

Uses. Buchu is regarded as possessing a tonic and diuretic action; it is used in inflammatory conditions of the urinary tract.

JABORANDI LEAVES. Folia Jaborandi, Jaborandi

Sources, etc. The name jaborandi is applied in South America, especially in Brazil, to a number of plants (belonging chiefly to the families Rutaceæ and Piperaceæ) possessing salivant and sudorific properties. The leaflets of several species of *Pilocarpus*, family Rutaceæ, have been imported as jaborandi, but the variety at present almost exclusively in commerce is obtained from *P. microphyllus* Stapf.

The plant produces imparipinnate compound leaves, mostly with three pairs of leaflets, which are collected, dried, and exported in large quantities to Liverpool, chiefly from Maranham; hence this variety is often distinguished as Maranham jaborandi.

Description. The leaflets are 2·5 to 4 cm. long, brownish-green, coriaceous, glabrous, obovate, deeply emarginate at the apex and more or less asymmetrical, with the exception of the terminal leaflet, which is symmetrical. By transmitted light oil-glands are visible under a lens. Odour characteristic, but not powerful; taste aromatic and pungent, a copious flow of

saliva being produced. The rachis, if present, is slightly winged. See Fig 31 B and C.

Constituents. Jaborandi leaves contain volatile oil (about 0·5 per cent.), resin and the alkaloids pilocarpine, *iso*pilocarpine and pilosine (carpiline). Of these alkaloids pilocarpine, $C_{11}H_{16}N_2O_2$, is the most important and the one upon which the therapeutical value of the leaves almost entirely depends. The proportion present is usually about 0·5 per cent.

Pilocarpine is crystalline (m. pt. 34°) and dextrorotatory; 0·01 gm. produces powerful sweating and salivation. Heating with alcoholic potash

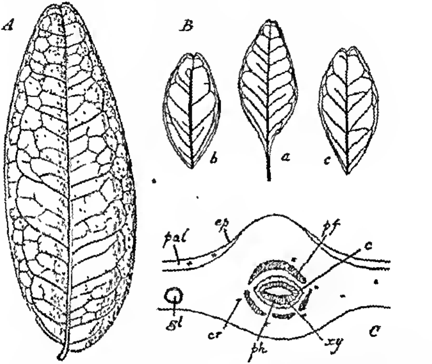

FIG. 31. Jaborandi. *A*, leaflet of *Pilocarpus jaborandi* Holmes. *B*, leaflets of *P. microphyllus* Stapf. *a*, terminal leaflet, *b* and *c*, lateral leaflets. *C*, transverse section of midrib of *P. microphyllus*. (*A*, after Maisch; *B*, after Wallis, *C*, after Duval); *c*, cambium; *cr*, cluster crystal; *ep*, epidermis; *gl*, oil-gland; *pal*, palisade; *p.f.*, pericylic fibres; *ph*, phloem, *xy*, xylem

converts it into the racemic form, isopilocarpine, which has about one-tenth of the activity.

Pilosine occurs in very small proportion only.

The therapeutical action of pilocarpine is not modified by the addition of isopilocarpine, pilosine, pilocarpidine (which occurs in the leaflets of *P. jaborandi* Holmes), or the resin; hence pilocarpine can well replace the drug for medicinal use (Jowett).

Uses. Jaborandi stimulates the parasympathetic nerve endings and induces therefore profuse salivation and perspiration. It is chiefly given as a powerful and rapid diaphoretic, and appears to be of most service in renal disease, eliminating both water and urea. Pilocarpine is used in ophthalmic surgery to contract the pupil of the eye; it is antagonistic to atropine.

Substitutes and Varieties. *Swartzia sp.*, family Leguminosæ; brownish

green, glossy; midrib minutely hairy; very short, hairy petiolule; *veinlets give a pellucid appearance to the lamina; about 3 cm. long but* some only 0·5 cm. long.

P. jaborandi Holmes; dull brownish-green, 6 to 10 cm. long, oblong-lanceolate, margin revolute, apex emarginate, unequal at the base, upper surface glabrous with prominent lateral veinlets, under surface sometimes slightly hairy. Formerly official but now seldom imported; contain pilocarpine (about 0·5 per cent.), isopilocarpine and pilocarpidine. See Fig. 31 A.

P. pennatifolius Lemaire; Paraguay Jaborandi; greyish-green, paler and less coriaceous than *P. Jaborandi*; veinlets not prominent on the upper surface; usually equal at the base. Contain about 0·25 per cent. of alkaloid.

P. Selloanus Engler; imported from Rio Janeiro; closely resemble the above, but are more obovate.

P. trachylophus Holmes; smaller than those of either *P. Jaborandi* or *P. pennatifolius*; dark olive-green on the upper, yellowish-green on the under surface, which is clothed with short curved hairs, similar ones being [illegible], contain about 0·4 per cent. of total [illegible] which only 0·02 per cent. is possibly [illegible]

P. spicatus (?); Aracati Jaborandi; resemble bay leaves in size and shape; upper surface polished, veins scarcely visible, outline lanceolate, petiole short and twisted.

P. racemosus Vahl; Guadeloupe Jaborandi; ovate, attaining 17 cm. or more in length; contain from 0·6 to 1·0 per cent. of total alkaloid, about one-half of [illegible]

Piper jal[illegible] y, papery leaves tapering towards bo[illegible] with the stems, which are swollen at the nodes.

EUCALYPTUS LEAVES. Folia Eucalypti

Sources. Eucalyptus leaves are obtained from *Eucalyptus globulus* Labillardier, family Myrtaceæ, the ordinary "blue gum" tree of Victoria and Tasmania, a tree which is cultivated in Italy, Spain, southern France, Portugal, Algeria, etc.

The tree bears leaves of two types; on young plants they are opposite,

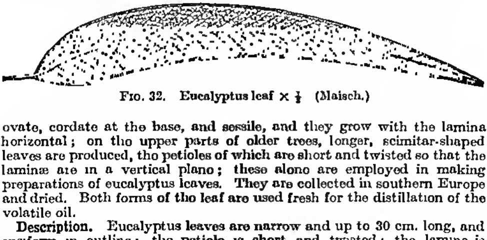

FIG. 32. Eucalyptus leaf × ½ (Maisch.)

ovate, cordate at the base, and sessile, and they grow with the lamina horizontal; on the upper parts of older trees, longer, scimitar-shaped leaves are produced, the petioles of which are short and twisted so that the laminæ are in a vertical plane; these alone are employed in making preparations of eucalyptus leaves. They are collected in southern Europe and dried. Both forms of the leaf are used fresh for the distillation of the volatile oil.

Description. Eucalyptus leaves are narrow and up to 30 cm. long, and ensiform in outline; the petiole is short and twisted; the lamina is thick, coriaceous, and, when quite dry, brittle; the margin is entire and

somewhat thickened; the midrib is not prominent on either surface, and the very numerous pinnate lateral veins anastomose near the margin to a continuous line; the apex is acute. The leaves are quite glabrous, but punctate from the presence of numerous oil-glands situated in the mesophyll. The surfaces are frequently marked with a number of minute, warty, brown spots; these are groups of cork cells that fill ruptured oil-glands.

The odour of fresh eucalyptus leaves is strong and camphoraceous; in the dry leaves it is less perceptible until they are crushed. The *taste* of the dry leaves is aromatic, pungent, and slightly bitter.

Histology. The cells of both upper and lower epidermis have straight anticlinal walls and a very thick cuticle and over each gland is a small patch of modified cells. Numerous sunken stomata of the ranunculaceous type are present in each epidermis. The leaves are isobilateral and there are two or three rows of palisade on each side. Large ovoid schizogenous oil-glands are embedded in the mesophyll, and here and there one has discharged its contents and become lined with a layer of cork. Prisms of calcium oxalate occur near the fibres of the veins and clusters of calcium oxalate in the palisade and spongy tissue.

Constituents. Eucalyptus leaves contain, when fresh, from 3 to 5 per cent. of volatile oil containing 50 or more per cent. of cineol (eucalyptol, cajeputol). They also contain tannin, a bitter principle which has not yet been investigated, and several resins, one of which is crystalline.

Uses. Eucalyptus leaves are used as an astringent; they have also been employed in the form of a cigarette for asthma. The volatile oil has antiseptic properties.

Note. The official eucalyptus oil may be obtained from *E. globulus E. dumosa* A. Cunningham, and other species. Much is imported from Australia. Citro-scented eucalpytus oil is obtained from *E. citriodora* Hooker (Queensland).

LAUREL LEAVES (Bay Leaves). The leaves if *Laurus nobilis* Linn., family Lauraceæ, cultivated in Great Britain. Leaves lanceolate-acuminate, 10 cm. or more long, coriaceous, pellucid-punctate, shining green, glabrous; margin entire, wavy; upper surface finely shagreened; aromatic. Contain 1 to 3 per cent. of volatile oil (chief constituents, cineol, eugenol, geraniol, terpenes). The oil of bay from which bay rum is made is obtained from the leaves of *Pimenta acris* Wight, family Myrtaceæ.

ERIODICTYON (Yerba Santa). Leaves of *Eriodictyon californicum* Green family Hydrophyllaceæ, California. Oblong-lanceolate, 5 to 15 cm. long, 1 to 3 cm. broad, acute; margin more or less incurved, entire or irregularly serrate; upper surface yellowish-green, smooth, covered with brownish resin; under surface whitish or yellowish-white, reticulated and densely tomentose; odour and taste aromatic. Contain eriodictyol and four allied substances all of phenolic nature, volatile oil and resin. Used as a tonic and expectorant; masks the bitter taste of some drugs.

BOLDO LEAVES. The leaves of *Peumus Boldus* Molina, family Monimiaceæ, Chili. Leaves ovate or elliptical, 4 to 8 cm. long, shortly petiolate, greyish-green, coriaceous, brittle; margin entire, slightly revolute; both surfaces with numerous emergences each crowned with a group of one-celled, thick-walled hairs (easily broken off), in the mesophyll numerous oil-cells; aromatic odour; pungent, camphoraceous, bitter taste. Contain volatile oil, boldine (alkaloid), and boldoglucin (glycoside). Used as a diuretic and liver stimulant.

CHERRY-LAUREL LEAVES. Folia Laurocerasi

Sources, etc. The cherry-laurel, *Prunus Laurocerasus* Linn., family Rosaceæ, is an evergreen shrub indigenous to Persia and Asia Minor, but cultivated in most temperate regions. The poisonous property of the water distilled from the leaves was not known till 1731; the poisonous principle contained in it was identified as hydrocyanic acid soon after the discovery of the latter by Scheele in 1782.

Collection. Collect the leaves which are just full grown, these are the leaves of the current year collected in June.

Description. Cherry-laurel leaves, which are used in the fresh state only, average about 15 cm. in length by 5 cm. in breadth. The upper

FIG. 33 *Prunus Laurocerasus*, L. Leaf and inflorescence. (After Lindley.)

surface is dark green and glossy, the under surface paler. In outline they vary from oblong-lanceolate to nearly obovate; the apex is acuminate and recurved; the lamina is thick, glabrous and coriaceous, the petiole is thick and grooved above; the margin is slightly recurved and distantly serrate. On the under surface of the lamina, near the base, and on either side of the midrib are from one to four yellowish, depressed spots; these spots are the remains of glands which secrete a sugary substance whilst the leaf is young.

When fresh and entire, cherry-laurel leaves are almost inodorous; but when crushed the young leaves evolve an odour recalling that of oil of bitter almond and hydrocyanic acid.

Constituents. The principal constituent of cherry-laurel leaves is a glycoside, prulaurasin, formerly known as laurocerasin. Prulaurasin, $C_{14}H_{17}NO_6$, has been obtained in colourless, odourless, bitter prisms (m.pt. 120°; o.r. — 53°·6). In contact with prunase (an enzyme also contained in the leaves) and water, prulaurasin is decomposed, yielding benzaldehyde, hydrocyanic acid, and dextrose.

$$\underset{\text{Prulaurasin}}{C_{14}H_{17}NO_6} + \underset{\text{Water}}{H_2O} = \underset{\text{Dextrose}}{C_6H_{12}O_6} + \underset{\text{Hydrocyanic acid}}{HCN} + \underset{\text{Benzaldehyde}}{C_6H_5CHO}.$$

So long as the leaves remain intact no decomposition takes place.

Fresh leaves from healthy plants yield on an average about 0·1 per cent. of hydrocyanic acid. In the autumn the yield is less than in the spring or early summer, the young leaves being especially rich in prulaurasin; newly unfolded leaves have yielded as much as 2·49 per cent. of hydrocyanic acid (Ven, 1898).

Prulaurasin resembles, but is not identical with, amygdalin. By acting upon amygdalin with yeast Fischer obtained an amygdonitrile glucoside, $C_6H_5.CH < {CN \atop O.C_6H_{11}O_5}$. This body is isomeric with prulaurasin, but differs in its optical rotation (− 26°·9), and yields, when acted upon by hydrochloric acid, lævo-phenylglycollic acid (mandelic acid), $C_6H_5.CH < {OH \atop COOH}$. Under similar conditions prulaurasin yields inactive (racemic) phenylglycollic acid. Hence prulaurasin is the glucoside of racemic phenylglycollic acid, and the amygdonitrile glucoside that of lævo-phenylglycollic acid. Sambunigrin, an allied glucoside contained in the leaves of the elder, is the glucoside of dextrophenylglycollic acid. Both the amygdonitrile glucoside and sambunigrin are readily converted into prulaurasin by dilute alkalies. (See also "Wild Cherry Bark.")

Uses. Cherry-laurel water is employed as a sedative, its action being due to the hydrocyanic acid it contains.

The crushed fresh leaves enclosed in a corked tube or bottle are used in preparing the "killing-bottle" used by many entomologists when collecting beetles and other small insects.

BEARBERRY LEAVES. Folia Uvæ Ursi

Sources, etc. The common bearberry, *Arctostaphylos uva-ursi* Sprengel, family Ericaceæ, is a small procumbent evergreen shrub distributed throughout central and northern Europe and North America. It is indigenous to Great Britain, but is confined to Scotland, the north of England, and Ireland. The plant sends out branching stems that take root, and so forms small clumps.

Collection. The leaves are collected in April, May and June and are dried in the open by the heat of the sun.

Description. Bearberry leaves are small, shining, coriaceous leaves, 10 to 25 mm. long and 5 to 12 mm. wide. The upper surface is olive-green or brownish green, the under surface paler. They are spathulate or obovate, the lamina being rounded at the apex, but tapering gradually towards the base to a very short petiole. They are more or less rigid, and, when quite dry, brittle. The margin is entire, slightly revolute, and, in young leaves, ciliate with short hairs, but these are scarcely discernible in the drug. The veins and veinlets are depressed on the upper surface, which thus assumes a chequered or wrinkled appearance; the greyish-green under surface is reticulately marked with somewhat darker veins, which are often slightly raised, but it does not show raised brown points when examined with a lens. The leaves have no marked odour, but are strongly astringent and somewhat bitter.

Histology. The midrib is transcurrent, having columnar collenchyma above and below the meristele, which consists of a radiate xylem and a bicollateral phloem separated by cambiform tissue; there are a few fibres above the xylem. In the collenchyma are numerous crystals of calcium oxalate, either single prisms or irregular crystals sometimes accompanied in the

same cell by numerous smaller crystals. The anticlinal walls of both epidermises are straight and stomata of the ranunculaceous type occur on the lower surface only and are grouped in patches over the vein-islets; there is a thick cuticle. Most of the cells of the mesophyll contain droplets of oil; the palisade is usually in three rows, occasionally four or five. A few unicellular conical thick-walled trichomes are present on the petiole and on the margin of the young leaves; there are also a few glandular trichomes, with a two-celled uniseriate stalk and a multicellular secreting head.

Constituents. Bearberry leaves contain both tannin and gallic acid; an infusion of the leaves accordingly gives a bluish-black precipitate with ferric salts. They also contain arbutin, methyl-arbutin, ursone, quercetin, and possibly myricetin.

[illegible] g at [illegible] d wi [illegible] quinone. A similar decomposition takes place when arbutin is administered by the mouth, both arbutin and hydroquinone being excreted by the urine; in fact, the activity of bearberry leaves is said to be partly due to the stimulant and antiseptic properties of the latter substance.

Quercetin, $C_{15}H_{10}O_7,2H_2O$ (tetraoxyflavonol), is a yellow crystalline body which is also obtained when the glycoside quercitrin, one of the constituents of quercitron bark (*Quercus discolor* Aiton), is hydrolysed by boiling with dilute mineral acids.

Substitutes. Bearberry leaves are seldom adulterated; the leaves of the box (*Buxus sempervirens* Linn.) and of the cowberry (*Vaccinium vitis-idæa* Linn.), reported to have been used, are easily distinguished, as the former are emarginate at the apex, and the latter have brown spots scattered over the under surface of the leaf.

Uses. Bearberry leaves are used as a stimulant, diuretic, and antiseptic in disease of the urino-genital tract; they resemble buchu in their action, but are more astringent.

[illegible] stomata on [illegible]; numerous prismatic and cluster crystals of calcium oxalate; taste bitterish and astringent; usually imported in coarse powder; contain 0 2 to 2 per cent. of caffeine and 10 to 16 per cent. of chlorogenic acid.

COCA LEAVES. Folia Cocæ

Sources, etc. The coca shrub, *Erythroxylum coca* Lamarck, and *E. truxillense* Rusby, family Erythroxylaceæ, has been cultivated in Peru and Bolivia for so long that the plant is not known in the wild state. It is cultivated also in Java and Formosa. The dried leaves are in almost daily use in Peru and Bolivia as a nerve-stimulant; mixed with lime or with ashes of a species of *Chenopodium* and chewed they impart unusual powers of endurance, allaying the cravings of hunger and the feeling of fatigue. Coca was used in Peru long before the discovery of America and small bags of the leaves have been found in the graves of the Incas. On the steep sides of the valleys in the spurs of the Andes the coca is cultivated in large quantities. Only a very small proportion of the coca produced is exported; by far the

greater part is consumed by the natives, whilst a considerable quantity is used in Callao for the manufacture of cocaine, the crude alkaloid being exported instead of the leaves.

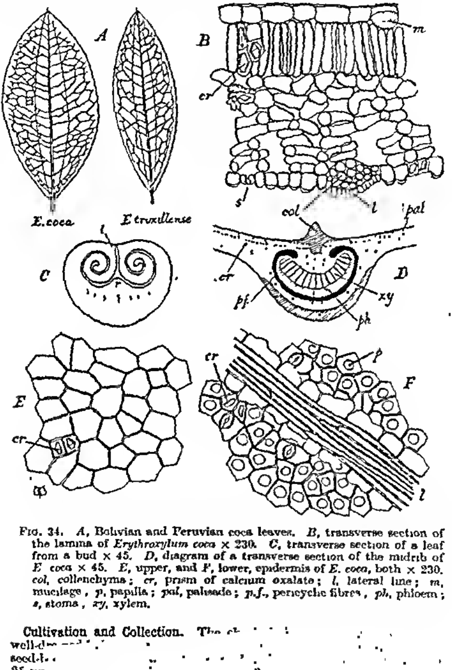

FIG. 34. *A*, Bolivian and Peruvian coca leaves. *B*, transverse section of the lamina of *Erythroxylum coca* × 230. *C*, transverse section of a leaf from a bud × 45. *D*, diagram of a transverse section of the midrib of *E. coca* × 45. *E*, upper, and *F*, lower, epidermis of *E. coca*, both × 230. *col*, collenchyma; *cr*, prism of calcium oxalate; *l*, lateral line; *m*, mucilage; *p*, papilla; *pal*, palisade; *p.f.*, pericyclic fibres; *ph*, phloem; *s*, stoma; *xy*, xylem.

Cultivation and Collection. The ch
well-d
seed-l
25 cm
years
two o
collect

in dry airy sheds or, in unfavourable weather, by artificial heat. Formerly the leaves were packed in
by means of a wooden pr
wrapped in plantain leav
65 kilos) made a load for a mule. It is now more usual to pack the leaves in wooden chests similar to those used for tea. A large amount of Java leaf is exported in coarse powder and sent to Holland.

Description. *Bolivian* coca leaves are usually fairly intact. They are brownish-green in colour, and oval in outline, about 4 to 8 cm. long and 2·5 to 4 cm. wide, the length being about twice the breadth. Both surfaces are glabrous, the margin is entire; the apex is acute and mucronate, the midrib projecting as a minute point (apiculus) which, however, is frequently broken o
depressed on the upper surface and
on the under surface on either side
curved line runs from the base to the apex of the leaf at a position about one-third of the distance from the midrib to the margin. This line is form
in the bud
other half (
consists of
the lateral veins and veinlets being comparatively strong and hence prominent on the upper surface. The lateral veins leave the midrib at a wide angle, often a right angle, and anastomose chiefly at about two-thirds the distance from the midrib to the margin. The odour is faint; the taste is slightly bitter, followed by a feeling of numbness in the mouth and throat. The small, oblong-ovoid, dark brown, pointed fruits are occasionally found in the drug.

Peruvian or *Truxillo* coca leaves are rather smaller than the Bolivian and more narrowly elliptical; they are about 3 to 6 cm. long and 1 to 2 cm. wide, that is, about three times as long as wide. They are pale green in colour and are more fragile, hence they are usually more or less broken. On the upper surface the ridge above the midrib is less marked, on the under surface the two curved lines are much less distinct, the veinlets less prominent, and the midrib green in colour. These leaves occasionally contain an admixture of the flowers of a species of *Inga*, easily recognised by their yellowish-brown, tubular, hairy calyx and numerous deep-red filaments forming a plume; this is an intentional addition, made by the native collectors with the view of improving the coca. The pale, reddish-brown fruits of the coca are also occasionally to be found.

Java coca is exported in the form of coarse powder; it does not reach the English market, but is exported in very large quantities to Holland and Japan for the extraction of cocaine.

Histology. The two leaves are very similar in structure; the meristele of the midrib possesses an arc of xylem and a band of phloem with a band of pericyclic fibres below and also some sclerenchyma above; there is usually, but not always, a gap on either side between the lower and upper sclerenchyma. The epidermis has straight anticlinal walls and stomata of the rubiaceous type on the lower surface only; the outer walls of the lower epidermal cells are papillose, giving in surface view the appearance

of a circle in the centre of each cell. Mucilage is present in a few of the epidermal cells. There is a palisade of one layer of cells and a few prisms and clusters of calcium oxalate are present in the mesophyll. The Bolivian leaf has a prominent ridge, filled with collenchyma, above the midrib, a marked development of sclerenchyma above and below the side veins and usually shows the presence of lignified idioblasts most abundantly near the lines of the undersurface; these characters distinguish the Bolivian leaf from the Peruvian leaf which never possesses lignified idioblasts and has only a very slight prominence over the midrib. The vein-islet number of Bolivian coca is 8 to 12 and that of Peruvian coca is 15 to 26. The stomatal index of *E. coca* is for the lower surface 12·0 to 13·3 to 15·4 and of *E. truxillense* is 8·4 to 10·1 to 11·5 (Rowson 1943).

Constituents. Coca leaves contain several alkaloids, the most important of which is cocaine, $C_{17}H_{21}NO_4$, which forms colourless monoclinic prisms with a bitter, benumbing taste. Bolivian leaves contain more of this alkaloid than the Peruvian, but the quantity is usually less than 1 per cent. Other alkaloids are cinnamyl-cocaine and α-truxilline (γ-isatropylcocaine, cocamine, isococamine); these are frequently present in Java and Peruvian leaves in larger quantities than cocaine. All these alkaloids are easily hydrolysed, and they all yield, together with other products, a crystalline alkaloid, ecgonine, from which cocaine can be regenerated. Thus cocaine, when hydrolysed, yields methyl alcohol, benzoic acid, and ecgonine; cinnamyl-cocaine yields methyl alcohol, cinnamic acid, and ecgonine; and truxilline yields methyl alcohol, truxillic acid, and ecgonine. Ecgonine is very closely allied to tropine.; α-truxilline is a powerful heart-poison. (See under "Belladonna Herb")

In leaves imported from Java benzoyl-pseudotropine or tropacocaine has been found; this alkaloid yields, when hydrolysed, benzoic acid and pseudotropine, the latter being isomeric with tropine. Tropacocaine is less toxic than cocaine; its anæsthetic action is more prolonged; it is used for lumbar anæsthesia. Java coca contains from 1 to 1·5 per cent. of total alkaloid, it also contains four yellow crystalline glycosides.

Coca leaves contain, in addition, cocatannic acid.

The alkaloids are localised chiefly in the epidermal cells, particularly those of the upper surface, and in some of the parenchymatous cells of the secondary veins

As most of the cocaine of commerce is prepared synthetically from ecgonine, coca leaves are now usually assayed for the amount of ecgonine it is possible to obtain from them

Uses. Coca is a stimulant tonic and restorative, and is used during convalescence. Cocaine hydrochloride, when administered hypodermically, or applied to an exposed mucous surface, rapidly paralyses the sensory nerves and thus produces local anæsthesia It is therefore of great value and much used in minor surgical operations of the eye, nose, ear, etc.

ALEXANDRIAN SENNA LEAVES. Folia Sennæ Alexandrinæ. Alexandrian Senna Leaflets, Senna Alexandrina

Sources, etc. Alexandrian senna consists of the leaflets of *Cassia acutifolia* Delile, family Leguminosæ, a small shrub from 1 to 1·5

metres in height, indigenous to and sometimes cultivated in the middle and upper Nile territories The medicinal value of the pods and leaves of the plant was known to the Arabian physicians of the tenth and eleventh centuries, through whom European physicians probably became acquainted with the drug. It was formerly exported from Alexandria, but now reaches the European market from Port Sudan.

Cultivation and Collection. Alexandrian senna is collected almost entirely from wild plants in the eastern part of Kordofan Province, in the White Nile Province, and along the course of the Nile from Khartoum to Dongola. Cultivation of some sort is becoming more common, especially in the neighbourhood of Khartoum, and results in the production of a larger and finer leaf. The branches are collected when the fruits are fully formed, but are still unripe; they are rapidly dried in the sun. The bulk is brought to Omdurman, where it is sold by auction under Government supervision. It is then cleaned and graded into whole leaves, whole and broken leaves ("*mixed*" or "*half-leaf*" senna), siftings and pods. The pods and large stalks are first sifted out and the pods separated by hand. That which has passed through the sieve is then "tossed" on large shallow trays, by which the whole and fragmentary leaves are separated from the heavier stalks and sand. The leaves are then freed from the small fragments and very small leaflets by sifting, giving "siftings" and "mixed leaves." From these mixed leaves the whole leaves, if required, are picked by hand. They are usually packed in mats or bales without pressing, railed to Port Sudan, and shipped thence (largely) to London.

Description. The plant produces a paripinnate compound leaf about 10 cm in length. The leaflets are about 2 to 4 cm. long and 7 to 12 mm. wide, and, when dried, are pale greyish-green, thin, and brittle, lanceolate to ovate-lanceolate in outline, the widest part being below the middle; the margin is entire and the apex acute and mucronate. They are unequal at the base, and on the under surface the veins are distinct; both surfaces of the leaf are pubescent, small whitish hairs being distinctly visible, especially near the veins. Leaves from cultivated plants are less rigid, thinner and narrower than those from wild. The leaves frequently appear in commerce in a more or less broken condition due to their brittle, papery texture. They curl slightly as they dry, and, being loosely packed, retain this appearance.

A small proportion of stalk, consisting mainly of rachis with a little stem and not usually exceeding 1 or 2 per cent., is always unavoidably present. The *leaf-rachis* is slender, about 7 to 10 cm. long, and has a [illegible] scars, [illegible] of the [illegible] nded [illegible] vascular bundle. The *stem* is present in very small amount, it is about 2 mm. in diameter and is slightly angled. See Fig. 35, *H* and *G*.

Alexandrian senna has a faint but characteristic odour and a mucilaginous, mawkish, unpleasant taste.

Histology. A transverse section through the midrib shows the palisade continuous over the meristele, but absent on the underside, where the midrib projects only slightly. The meristele consists of a radiate xylem

and phloem with an arc of pericyclic fibres below and a compact mass of sclerenchyma above. The lamina is isobilateral, having a single layer of palisade beneath each epidermis. The anticlinal walls of the epidermal cells are straight and there are stomata of the rubiaceous type on both surfaces in about equal numbers. Many of the epidermal cells contain mucilage deposited upon the inner periclinal walls to fill about half the volume of the cells; this mucilage stains red with ruthenium red reagent. The epidermal trichomes are unicellular, conical, thick-walled and with a warty cuticle; they are often curved near the base so that the limb is appressed to the epidermis; they are about 70 to 260 microns long and 12 to 18 to 25 microns wide. The palisade cells of the upper side are longer than those of the lower side, which latter have wavy anticlinal walls. The veins are of two types, larger ones which form a network and are accompanied by prisms of calcium oxalate about 4 to 10 to 20 to 25 microns and within the meshes of these larger veinlets, a network of more slender veinlets, which are not accompanied by crystals. Cluster crystals, 8 to 15 to 20 to 30 microns, occur in the palisade and spongy tissue, but not usually near the veins. The vein-islet number is twenty-five to thirty and the palisade ratio is 4·5 to 9·5 to 18 for the upper epidermis and of 3·5 to 7·0 to 14·5 for the lower epidermis (George, 1943).

The stomatal index for both surfaces is 11·4 to 12·2 to 13·0 (Rowson, 1943). These numerical values are all available to distinguish Alexandrian from Indian senna and can be used in support of one another; see also under Indian senna.

Constituents. The chief constituents of Alexandrian senna are rhein, aloe-emodin, kæmpferin and isorhamnetin, all four substances occurring both free and in the form of glycosides, kæmpferol, myricyl alcohol and a phytosterolin (phytosterol glucoside) are also present (Tutin, 1913). The leaves contain in addition mucilage, calcium oxalate, resin, and amorphous glycosidic material.

Aloe-emodin, $C_{14}H_5O_2(OH)_2CH_2OH$, brownish-green needles, is hydroxymethyldihydroxyanthraquinone and is the primary alcohol corresponding to chrysophanic acid (better termed chrysophanol), which is dihydroxymethylanthraquinone. *Rhein*, $C_{14}H_5O_2(OH)_2COOH$, orange needles, is the corresponding carboxylic acid and may be formed by the oxidation of aloe-emodin. Both aloe-emodin and rhein exist in the free state and in the form of glycosides.

Kæmpferol, $C_{15}H_6O_2(OH)_4$, is 1 : 3 . 4-trihydroxyflavonol (bright yellow needles), and is yielded together with dextrose by the hydrolysis of kæmpferin, $C_{27}H_{30}O_{16}, 6H_2O$.

Isorhamnetin, $C_{16}H_{12}O_7$, yellow needles, was first obtained from yellow wallflowers.

Of these constituents aloe-emodin and its glucoside appear to be the only purgative ones. The total amount of methylanthraquinone derivatives present in senna has been variously estimated at 1·0 to 4·0 per cent. Maurin (1927) found in the leaves of *C. acutifolia* 1·55 per cent, and in those of *C. angustifolia* 1·35 per cent, a proportion that is not consistent with the purgative action of the drug, and the true active constituent is apparently still unknown. The presence of anthraquinone derivatives may be shown by the test given under "Rhubarb," p. 320.

Substitutes and Adulterants. *Cassia obovata* Colladon (dog senna), Upper Egypt, formerly highly valued as a drug, and cultivated in Italy and sometimes termed Italian senna, leaves broadly obovate, apex abruptly tapering, venation pinnate, distinct; constituents

similar to those of senna; total oxymethylanthraquinones 3·8 per cent. (according to Maurin, 1·10 per cent.); about equal to senna in activity. The leaves are sometimes broken up and mixed with broken Alexandrian senna; they may be recognised by the papillose cells of the lower epidermis.

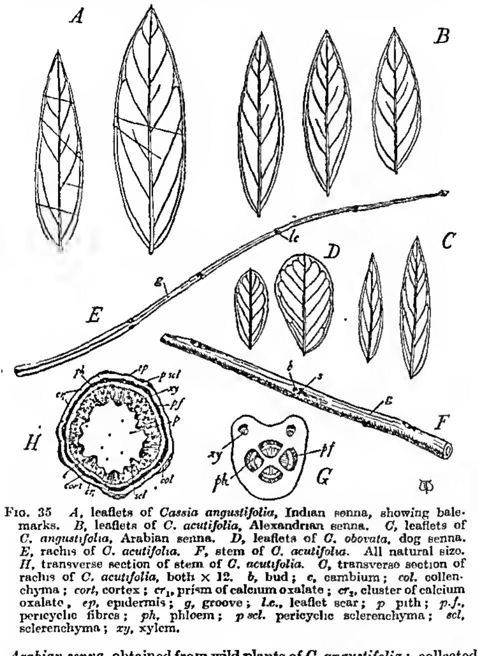

FIG. 35 *A*, leaflets of *Cassia angustifolia*, Indian senna, showing bale-marks. *B*, leaflets of *C. acutifolia*, Alexandrian senna. *C*, leaflets of *C. angustifolia*, Arabian senna. *D*, leaflets of *C. obovata*, dog senna. *E*, rachis of *C. acutifolia*. *F*, stem of *C. acutifolia*. All natural size. *H*, transverse section of stem of *C. acutifolia*. *G*, transverse section of rachis of *C. acutifolia*, both × 12. *b*, bud; *c*, cambium; *col.* collenchyma; *cort*, cortex; cr_1, prism of calcium oxalate; cr_2, cluster of calcium oxalate, *ep*, epidermis; *g*, groove; *l.c.*, leaflet scar; *p* pith; *p.f.*, pericyclic fibres; *ph*, phloem; *p scl.* pericyclic sclerenchyma; *scl*, sclerenchyma; *xy*, xylem.

Arabian senna, obtained from wild plants of *C. angustifolia*; collected in southern Arabia, shipped from Hodeida to Port Sudan and railed thence to Cairo, where they are cleaned and graded similarly to Alexandrian senna and exported. Elongated lanceolate; inferior qualities often discoloured and mixed with stalks; sometimes mixed with Alexandrian senna, but may be distinguished by the shape and

also by the vein islet numbers (see p. 104). They contain about 2·5 per cent. of total oxymethylanthraquinones.

Mecca or *Bombay senna* is also obtained from *C. angustifolia* in Arabia; the leaflets are usually more elongated and the colour darker.

The leaves of the following planta have also been reported as mixed with or substituted for senna :—

Cassia auriculata Linn. (Paltbé Senna); small, oblong or obovate co ... curved; cn

... veins, ... Egypt, Nubia, Kordofan; resemble senna in colour and outline, but are distinguished by their thick, rigid texture and peculiarly curled, curved, or twisted appearance; surface finely wrinkled; veins not evident; leaf equal at the base; hairs three-celled; taste distinctly bitter; formerly regularly mixed with the senna but now of rare occurrence.

... obovate-oblong, ... fruits narrow-

Colutea arborescens Linn., family Leguminosæ; green, very thin.

Ailanthus glandulosa Desf. Large triangular-ovate leaflets 7 to 10 cm. long, strongly striated cuticle, no stomata on upper epidermis, cluster crystals near veins. See p. 285.

Globularia Alypum Linn., family Globulariaceæ; (Provence Senna); spathulate, rounded apex, mucronate; prisms of calcium oxalate in the epidermal cells.

Coriaria myrtifolia Linn., family Coriariaceæ; ovate-lanceolate, greyish-green, two prominent lateral veins, conspicuous midrib.

Uses. Senna stimulates the muscular coat of the intestine and produces purgation, which is not followed, as is commonly the case, by constipation; it is therefore one of the most useful of purgatives, especially in cases of habitual constipation.

INDIAN SENNA LEAVES. Folia Sennæ Indicæ. Senna Indica, Tinnevelly Senna, Sennæ Folium, B.P.

Source, etc. Indian or Tinnevelly senna consists of the leaflets of *Cassia angustifolia* Vahl, which is indigenous to southern Arabia, but is cultivated largely in southern India, especially in the district of Tinnevelly, in the extreme south-east. Here the plant attains an unusual luxuriance, and produces larger leaves than the Arabian wild plant.

Cultivation and Collection. Tinnevelly senna is cultivated on irrigated land. The leaves are carefully collected from the plants by women and are spread out to dry; they are then sorted and packed into large bales, using hydraulic pressure. The drug is exported from Tuticorin.

n shape, less conspicuously asymmetrical and less pubescent. They are somewhat firmer in texture than the Alexandrian, and are consequently less broken when they arrive, and, being exported in

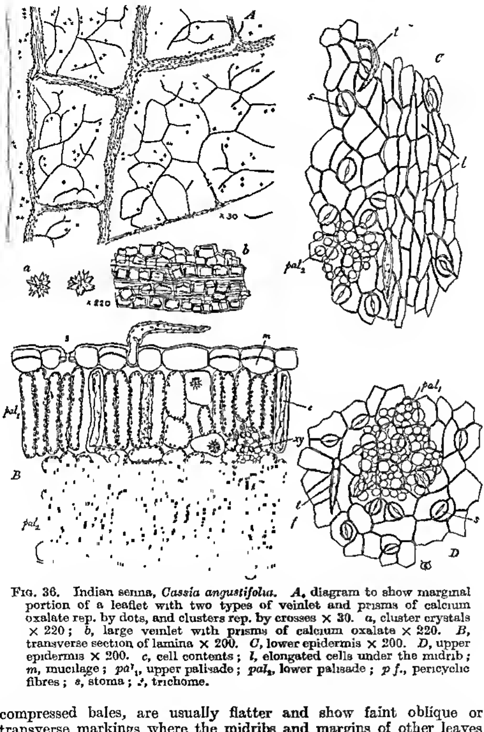

FIG. 36. Indian senna, *Cassia angustifolia.* *A*, diagram to show marginal portion of a leaflet with two types of veinlet and prisms of calcium oxalate rep. by dots, and clusters rep. by crosses × 30. *a*, cluster crystals × 220; *b*, large veinlet with prisms of calcium oxalate × 220. *B*, transverse section of lamina × 200. *C*, lower epidermis × 200. *D*, upper epidermis × 200. *c*, cell contents; *l*, elongated cells under the midrib; *m*, mucilage; pal_1, upper palisade; pal_2, lower palisade; *p f.*, pericyclic fibres; *s*, stoma; *t*, trichome.

compressed bales, are usually flatter and show faint oblique or transverse markings where the midribs and margins of other leaves have been impressed. There is also a slight but perceptible difference in the odour of the two varieties. It is, however, quite possible to

select from the two varieties exceptional leaves that are indistinguishable from one another.

Histology. The structure of Indian senna is closely similar to that of Alexandrian senna and it is not possible to distinguish powders of the two varieties by microscopical examination. It has been stated that differences in the number of trichomes and the distance between them and also in the arrangement of the subsidiary cells of the stomata can be used to distinguish the two varieties, but these characters are unreliable. Fragments of broken leaves, if of sufficient size, can be distinguished by the vein-islet number, which for Indian senna is twenty to twenty-three. Smaller fragments such as are present in fine powders, *e.g.*, No. 90, can be distinguished by the palisade ratio and by the stomatal index. The palisade ratio for the upper surface is 4·0 to 7·5 to 12·0 and for the lower surface 2·5 to 5·1 to 10·5 (George, 1943), the stomatal index is for both surfaces 17·1 to 18·7 to 20·0 (Rowson 1943)

Constituents. The constituents of Tinnevelly senna are identical with those of Alexandrian senna

Substitutes and Adulterants. Tinnevelly senna is usually free from adulterants.

WITCH-HAZEL LEAVES. Folia Hamamelidis. Hamamelis Leaves

Sources, etc. The witch-hazel, *Hamamelis virginiana* Linn., family Hamamelidaceæ, is a common shrub in the United States and Canada. It attains a height of about 3 metres, and somewhat resembles the common hazel in its leaves. The dried leaves alone are official, but the fresh leaves and twigs are employed for the preparation of Liquor Hamamelidis. The bark also is used in medicine.

Collection. The leaves are collected in the autumn and are carefully dried by the sun's heat by spreading them on shallow trays which are stacked in rough sheds, about 1·5 metres high, with open sides and a sloping roof of corrugated iron. The shade provided by the sheds protects the leaves from the direct action of the light and heat of the sun and so results in producing a commercial leaf with a good green colour

Description. Commercial witch-hazel leaves are usually in a somewhat indifferent state of preservation, being frequently discoloured, broken, and pressed together into more or less compact masses. Well-preserved full-grown leaves are of a dark green or brownish-green colour, about 4 to 15 cm. long and 3 to 10 cm. wide. They are broadly ovate or rounded-obovate, the base of the lamina is oblique and usually cordate; the petiole is short, the apex is acute, but is often imperfect and then apparently obtuse. The margin is coarsely crenate or even sinuate. On the under surface the midrib is prominent, and the lateral veins, which are also very distinct, branch from it at an acute angle, and run straight to and terminate in the crenations of the margin. In the angles thus formed and on the veins trichomes—which have a characteristic branching form—are usually to be found; they are more frequent on young leaves, very young leaves being brown in colour and densely hairy. The leaves have only a slight odour, but a decidedly astringent and somewhat bitter taste.

Associated with the leaves is a small proportion of the stems including some pieces with fruits attached. The amount of stem should not exceed about 3 per cent. Externally the stems are greyish-brown; the ordinary twigs are slender with elongated internodes, about 3 or 4 cm. long, and alternate leaf-scars; the flowering stems are rather thicker, with very short internodes and bear small fruits. The transversely cut surface of the twig shows an outer thin layer of cork, beneath which is a narrow cortex; at the centre is a small irregular pith surrounded by a radiate xylem, outside which is a narrow phloem with numerous small groups of lignified fibres and a pericycle composed of a narrow band of sclerenchyma.

The fruit is a small woody capsule, two-celled, dehiscing at the apex to form two halves and containing two seeds, which are edible.

Histology. The midrib projects strongly on the undersurface of the leaf and contains a *meristele* which consists of a central pith surrounded by a

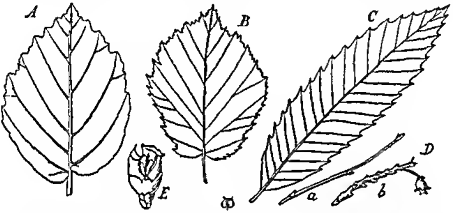

FIG. 37. Leaves of *A*, *Hamamelis virginiana*; *B*, *Corylus avellana* Linn. (common hazel); *C*, *Castanea vulgaris* Lam (sweet chestnut); *E*, fruit of *Hamamelis virginiana*, *D*, *a*, elongated shoot and *b*, dwarf flowering shoot of *Hamamelis virginiana*.

cylinder of xylem, cambium and phloem, above which, and separated from it by parenchyma and phloem, is a gutter-shaped xylem mass with phloem on the underside. As the apex of the leaf is approached, the tubular xylem opens above to form a trough, which gradually becomes more shallow, and the upper xylem ultimately disappears. Surrounding the whole vascular tissue is a sclerenchymatous pericycle, external to which is an endodermis having prisms of calcium oxalate, about 10 to 35 microns in diameter, in its cells. The *epidermal cells* of both surfaces have markedly wavy anticlinal walls and on the lower surface only there are stomata of the rubiaceous type. Stellately arranged trichomes consisting usually of four to twelve unicellular branches, and more rarely solitary unicellular trichomes, occur on the lower surface; the palisade consists of a single layer of cells and is discontinuous over the midrib. In the mesophyll are occasional lignified linear idioblasts, which usually extend completely across the lamina; there are also numerous tannin cells. See Fig. 29, p. 105.

Constituents. Witch-hazel leaves contain hamameli-tannin, gallic acid, a little phlobatannin, calcium oxalate and in the fresh leaves a trace of volatile oil.

By distilling the fresh or dried leaves with water or dilute alcohol, a distillate is obtained possessing a distinct aroma, different from that of the

leaves themselves, due probably to some product of decomposition. Liquor Hamamelidis (1914), which is made by macerating the fresh leaves with dilute alcohol and distilling, contains, in addition to the aromatic body alluded to, a trace of protocatechuic acid.

Hamamelin is a mixture of substances obtained by extracting the leaves, or sometimes the bark, with strong alcohol and evaporating the tincture thus obtained.

Uses. Witch-hazel leaves are astringent and hæmostatic.

Adulterants. Leaves of the chestnut, *Castanea vulgaris* Lam., sometimes occur admixed with witch-hazel; they are distinguished by their oblong-lanceolate shape, sharply serrate margin, closer arrangement of the side veins and the sub-rectangular shape of the vein-islets. Leaves of *Corylus avellana* Linn., the common hazel, have also been reported as an adulterant. They are distinguished by their broader shape and biserrate margin, see Fig 37 *B*.

HENNA LEAVES. The leaves of *Lawsonia alba* Lamarck (*L. inermis*, *Linn., family Lythraceæ*), *a shrub indigenous to* Egypt, Arabia, Persia, India. Leaves greenish-brown, oblong or broadly lanceolate, opposite, simple, glabrous, entire, shortly petiolate, mucronate, tapering at the base; 2 to 3 cm. long, 1 to 2 cm. wide; with occasional stems and brown, spherical fruits with thin pericarps and numerous, small, brown, triangular pitted seeds; often imported in coarse powder; decoction orange-brown, fading on the addition of acid, deepening with alkalies. Contain lawson, $C_{10}H_6O_3$, *orange crystals melting at* 190° to 195° (2-hydroxy-1,4-naphthoquinone) and mannite.

Uses. Henna leaves are used chiefly as a dye for the hair.

RASPBERRY LEAF.
Rubi Idæi Folium

Sources. Raspberry leaf consists of the dried leaflets of *Rubus Idæus* Linn., family Rosaceæ. The raspberry is indigenous to and is widely cultivated in Britain.

Collection. The leaves are removed from the canes after the collection of the fruits. The leaflets are stripped from the rachis and spread out to dry in airy sheds or in drying chambers at a low temperature.

Description. The drug occurs as more or less compressed masses of crumpled and folded leaflets which are sometimes also coarsely chopped. The leaf of the raspberry is imparipinnate with three to five leaflets,

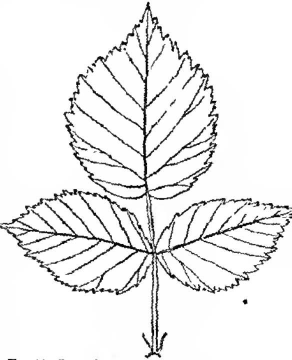

FIG 38. Leaf of *Rubus Idæus* Linn., the raspberry. Two-thirds natural size.

which are sessile on the rachis. The leaflets are about 3 to 12 cm. long and 1·5 to 9 cm. wide, the lateral leaflets being ovate and the terminal ones usually larger and somewhat cordate at the base. The lamina is entire; venation pinnate; the midrib sometimes bears a few small prickles on the basal part of the undersurface and it terminates in the apex, beyond which it forms a fine projection; the secondary veins terminate in the apices of the marginal teeth, each of which has a fine projection; the margin is irregularly serrate; the apex is acute or acuminate; the upper surface is olive-green, with a few appressed, glistening trichomes, the lower surface is greyish-white and tomentose; texture, thin and brittle. They have a slightly astringent taste and a pleasantly aromatic odour.

Constituents. Raspberry leaves contain tannin and a water-soluble principle which relaxes the smooth muscle of the uterus and intestine when in tone; the same principle contracts the uterus when not in tone.

Uses. An infusion 1 in 20 of hot water is used as an astringent gargle and also for relieving pain arising from the activity of the uterus.

FOXGLOVE LEAVES. Folia Digitalis. Digitalis Folium

Sources, etc. The purple foxglove, *Digitalis purpurea* Linn. family Scrophulariaceæ, is a biennial herb, widely distributed throughout Europe and common in England, where it is cultivated as a garden plant, as well as for medicinal use. It appears to have been long used as a domestic medicine for external application; it was introduced into the London Pharmacopœia in 1650, although it did not come into frequent use until about a century later, when its therapeutical properties were investigated by Withering (1776–1779).

Cultivation and Collection. Because of their small size, the seeds are mixed with sand for sowing, which is done in seed-beds in the autumn.

August. Next year the flowering stems, which begin to appear, are cut

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several years in succession, instead of dying down at the end of the second year as usually happens when the plant is allowed to flower and fruit freely.

The leaves are *collected* in dry weather and are dried as rapidly as possible at a fairly low temperature. The drying should be done in darkness and two methods are used. By one common method the leaves are spread on trays with a fairly fine wire netting bottom and stacked on runners in a well-closed, dark, drying-shed heated by hot air from a furnace in the basement and ventilated above; this process takes from four to ten days. A second method of drying is to put the leaves on the heated shelves of a vacuum drying-oven when the whole operation is completed in a few hours. The dried leaves are *stored* in the drying rooms till needed for distribution, when they are packed in well-filled, air-tight containers such as well closed tins or the powder may be put into small bottles or ampoules. When the leaves are packed the moisture present should not exceed 5 per cent.

Description. Foxglove leaves are usually about 10 to 20 cm. long and 4 to 10 cm. wide, but under cultivation may become as much as

40 cm. long and 15 cm. wide; the upper surface is deep green and greyish, the lower pale green and more grey; the lamina is ovate-lanceolate to broadly ovate, simple and entire; the margin is crenate to serrate and the base decurrent; the venation is pinnate, the side veins leaving the midrib at an angle usually less than 45 degrees, curving towards the apex and anastomosing near the margin; a

FIG 33 *Digitalis purpurea* 1 Inflorescence 2 Foliage leaf 3 Corolla, laid open 4 Young fruit 5 Ripe fruit 6. Transverse section of the ovary 7 Seeds × 15 8 Tooth of the margin × 5

veinlet ends in each tooth of the margin and the veinlets generally are prominent on the under surface of the leaf; the upper surface is pubescent and the lower surface strongly pubescent, the texture is papery; the petiole is short and winged, the lowest veins running down the wings, the odour is somewhat tea-like and the taste bitter

Histology. The *midrib* projects strongly on the lower surface and contains a meristele having a shallow gutter-shaped radiate xylem, beneath which is a narrow phloem and on the upper side a little parenchyma; below the phloem is a pericycle of small-celled collenchyma and the whole meristele is surrounded by an endodermis containing starch granules, the remainder of the tissue of the midrib is thin-walled cellulosic

and 3 molecules of a sugar named digitoxose while gitoxin yields gitoxigenin and 3 molecules of digitoxose. Gitalin, when hydrolysed, yields gitoxigenin-hydrate and 2 molecules of digitoxose. There are therefore at least five glycosides in dried foxglove leaves, and in addition a yellow flavone colouring matter, luteolin and a saponin, digitsaponin.

Digitoxin (0·2 to 0·3 per cent.), $C_{41}H_{64}O_{13}$, is a well-defined, colourless, odourless, crystalline, bitter substance, insoluble in water, but nevertheless passing into solution in appreciable quantity when foxglove leaves are infused in that menstruum. It is the most toxic of the active constituents of the leaves, and is cumulative in action, being apparently fixed by the muscles of the heart. It may be identified by Keller's reaction, which consists in dissolving it in glacial acetic acid, adding a drop of ferric chloride solution, and then, gently, a stratum of sulphuric acid; the upper part of the latter is coloured red, whilst above this an indigo blue band gradually appears. The first year's leaves contain as much digitoxin as the second, the quantity of digitoxin, however, rapidly diminishes towards the end of the flowering stage.

Gitalin (0·3 to 0·9 per cent.) is soluble in water; it has a marked action on the heart, and as it is not cumulative it is believed to be more valuable therapeutically than digitoxin.

Digitoxose is a sugar peculiar to foxglove, it is regarded as a derivative of pentose and is described chemically as deoxymethylpentose.

The active constituents of foxglove seeds are: *Digitoxin* (see above). *Digitalin*, a crystalline, water-soluble, active glycoside. *Digitonin*, a crystalline saponin.

The digitalins of commerce appear to be variable mixtures.

Uses. Foxglove leaves increase the activity of muscular tissue, especially that of the heart and arterioles, and is employed in most forms of cardiac failure. Digitoxin is cumulative, and the action of preparations of foxglove must therefore be watched.

Related Drugs. The leaves of the following species of *Digitalis* occur as articles of commerce and are used medicinally in the same way as the leaves of *D. purpurea*.

Digitalis lutea Linn., is a plant similar in general habit to *D. purpurea*, but with smaller flowers, having yellow corollas; it is a native of southern and western Europe and is cultivated in the United States of America. The sessile leaves are up to 28 cm. long and 6 cm. wide, but the majority are not above half that size. They are oblanceolate, with an indistinctly serrate or dentate margin having irregularly spaced teeth and fringed with long trichomes in the basal half of the leaf, which is otherwise almost glabrous; the main veins are few, they leave the midrib at a very acute angle and travel for some distance towards the apex, while the smaller branches are inconspicuous, thus giving an appearance simulating a parallel venation. Physiological tests show that this leaf is about equal in potency to that of *D. purpurea*. Calcium oxalate is absent. The constituents have not been investigated.

Digitalis lanata Ehrh. is a species which grows in the region adjacent to the Danube in Central Europe; it has been cultivated in England and in the United States of America. The plants generally resemble those of *D. purpurea*, but the shape of the corollas is different and the pedicels are covered with woolly trichomes. The leaves are sessile and about the same size as those of *D. lutea*; they are oblong lanceolate; the margin

is entire and in the basal half ciliate with long uniseriate trichomes, otherwise the leaf is glabrous. The venation resembles that of *D. lutea*. Physiological tests have shown the leaves to be from twice to four times as active as those of *D. purpurea*. Calcium oxalate is absent. The constituents are the crystalline glycosides digitoxin, gitoxin, digoxin, lanadigin and digilanids A, B and C. Lanadigin is apparently identical with digilanid C. The three digilanids consist respectively of digitoxin, gitoxin and digoxin in combination with in each case an acetyl group and a molecule of dextrose.

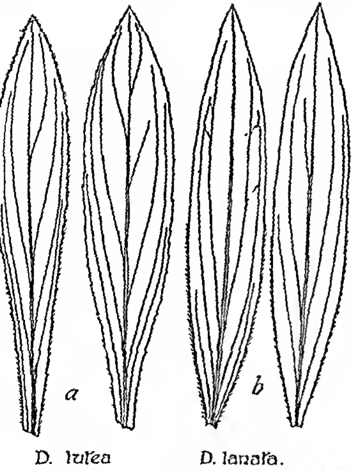


FIG. 41. Typical leaves of *Digitalis lutea* and *D. lanata*.

Digitalis Thapsi Linn. Spanish foxglove. The leaves are from 5 to 15 cm. long and 1·5 to 5 c.m. wide; they are dark yellowish-green, lanceolate to oblanceolate and have an irregularly serrate to dentate margin; both surfaces are densely covered with long, uniseriate glandular trichomes and the cuticle is strongly striated; non-glandular trichomes are absent. Pericyclic fibres are present in the meristele and prisms of calcium oxalate are scattered throughout the mesophyll. The potency is from 1·25 to 3 times that of *D. purpurea*. The constituents have not been investigated.

Adulterations. *Mullein leaves* (*Verbascum Thapsus* Linn., family Scrophulariceæ); woolly; branched trichomes, known as candelabra trichomes.

Comfrey leaves (*Symphytum officinale* Linn., family Boraginaceæ);

lanceolate or ovate; isolated stiff unicellular trichomes, many of them curved into a hook at the apex.

Primrose leaves (*Primula vulgaris* Hudson, family Primulaceæ); nearly spathulate; lateral veins straight, dividing near the margin; trichomes uniseriate four to nine cells long, also short glandular trichomes with a unicellular stalk and a globular unicellular head.

Ploughman's spikenard leaves (*Inula Conyza* de Candolle, family

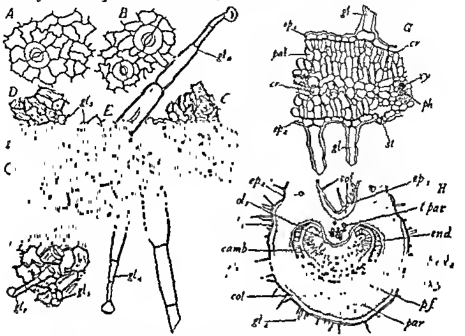


FIG. 42. *Digitalis Thapsi* A, B, C, D, E and F, epidermis in surface view. × 115. A, water pore occurring singly. B, group of two water pores. C, lower epidermis, interneural. D, lower epidermis beneath a vein. E and F, upper epidermis, interneural. *st*, stoma; gl_1, glandular trichome with bicellular head and unicellular stalk; gl_2, gl_3, gl_4, gl_5, gl_6, gl_7, glandular trichomes with unicellular heads. G, transverse section of the lamina × 115. *cr*, crystal of calcium oxalate in the form of a prism; ep_1, upper epidermis; ep_2, lower epidermis; *gl*, base of glandular trichome; *pal*, palisade; *ph*, phloem; *st*, stoma; *xy*, xylem. H, diagram of transverse sections of midrib × 20. *camb*, cambium; *col*, collenchyma; *end*, endodermis; *par*, parenchyma; *p.col.*$_1$, pericyclic collenchyma above xylem of meristele; *p.col.*$_2$, pericyclic collenchyma beneath phloem of meristele; *p.f.*, pericyclic fibres; *ph*, phloem; *t par.*, thickened parenchyma; *v.b*, small vascular bundle. Other lettering as above. All after Dewar.

Compositæ); margin either entire or dentate, with horny points to the teeth.

Elecampane leaves (*Inula Helenium* Linn., family Compositæ); lower lateral veins not decurrent.

TEA. Folia Theæ

Sources. The tea shrub, *Thea sinensis* Linn. (= *Camellia Thea* Link) family Theaceæ, has been cultivated from time immemorial in China and Japan and more recently [illegible]

[illegible] rom seed and are [illegible] They commence

to yield tea at the third year and reach their full yield at about the sixth year. For the best teas the bud and the first two leaves are removed from each shoot and for coarser varieties the third leaf also is collected. The leaves are first *withered*, *i.e.*, spread on trays to a thickness of about 1 lb. per sq ft and allowed to stand in the open for eighteen to twenty-four hours. They are next *rolled*, usually between two flat surfaces, a process which breaks the cellular structures of the leaf and liberates the cell sap and other cell contents, at the same time the leaves acquire the characteristic twist After rolling the leaves are *fermented* by laying them on slabs of concrete, glass or other non-porous material and maintaining a temperature of 20° to 27° C. in a carefully [illegible] The colour of the leaves chan[illegible] a period of two to four hours

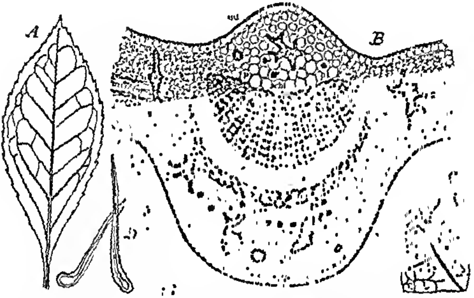


Fig 43. *Thea sinensis* Linn. Tea leaf. *A*, entire leaf natural size *B*, transverse section through the midrib. *hd*, hypoderma, *g*, vessels in wood; *p*, parenchyma; *s*, sieve tissue; *sch*, sclerenchymatous fibres; *sp*, stoma; *st*, sclerenchymatous idioblasts. × 120. (Warnecke) *C*, marginal tooth cleared by chloral hydrate, showing glandular tip and distribution of sclereids and crystals of calcium oxalate. *D*, unicellular trichomes, × 200

named thease, which converts the tannin into an insoluble reddish-brown phlobaphene, and the chlorophyll also undergoes change. The next process is *firing* or drying at a temperature of about 65° C., for which purpose the leaves, placed on trays, are carried on an endless band through a heated chamber until the moisture present is about 3 per cent. The tea is finally *sifted*, graded and packed.

In the manufacture of *green tea* the leaves are subjected to a process of roasting in pans heated by direct fire, in which they are kept continually moving; they are then cooled, rolled into balls, and allowed to ferment. In this case the preliminary roasting probably destroys some at least of the various enzymes of which the thease is composed, the tannin is not oxidised, and the leaves retain their green colour more or less unchanged

Description. The full-grown tea leaf is from 5 to 10 cm. long, dark green in colour, glossy on the upper surface, lanceolate or elliptical in

outline and blunt or acuminate at the apex, tapering at the base into a short stalk; the margin is distantly and shortly serrate, the serrations terminating in characteristic, glandular teeth which readily break off and are often absent from mature leaves. When quite young the leaves are covered with silky hairs, but as they mature these are lost, and the surface becomes almost glabrous. This difference is readily observed in commercial tea, the bud still bearing numerous hairs ("flowery" Pekoe), while the larger leaves are glabrous or nearly so (Congou)

Histology. The midrib is prominent below and has a broad ridge above; the palisade is discontinuous over the *meristele*, which shows in transverse section an arc of xylem with phloem below, the whole being surrounded by a slightly lignified band of pericyclic fibres about four fibres broad at the widest part, the ground tissue is composed of rounded parenchyma and contains numerous branching, lignified sclereids The *epidermal* cells are polygonal tables with very slightly wavy anticlinal walls, stomata occur on the lower surface only, where they are numerous, each being surrounded by about three very narrow, tangentially elongated cells. Unicellular, thick-walled, conical-linear *trichomes* occur on the lower surface and are very numerous on the youngest leaves. The *mesophyll* has two rows of palisade and large lignified sclereids (idioblasts) occur at intervals, usually stretching across the mesophyll from one epidermis to the other; cluster crystals of *calcium oxalate* are scattered throughout the parenchyma and occur also in the phloem of the meristele The marginal *teeth* are characteristic; each ends in a small conical point, which is glandular in nature and consists of an external layer of palisade covering a small mass of polyhedral parenchyma; these conical points fall off in older leaves and a brown scar remains.

Constituents. The principal constituents of tea are caffeine and tannin. It contains in addition traces of theobromine, theophylline, adenine, xanthine and volatile oil.

Caffeine or trimethylxanthine, $C_5H(CH_3)_3N_4O_2,H_2O$, an alkaloid obtainable in colourless silky crystals melting at 235°, was isolated from coffee by Runge in 1820 and from tea by Oudry in 1827. It occurs also in maté (the leaves of *Ilex paraguensis* Lambert, family Aquifoliaceæ, which are largely used in the Argentine Republic as tea is in this country), in cola seeds, in guarana, in the leaves of the coffee plant, etc. Tea contains from 1 to 5 per cent. (usually 3 to 4), nine-tenths of which is apparently in combination with tannin, the combination being decomposed by water and the caffeine liberated, during the process of fermentation, the percentage of free caffeine increases The tannin varies from 10 to 24 per cent But the commercial value of tea is not determined by the percentage of caffeine or of tannin contained in it, but by a combined consideration of several factors, such as the appearance, the size of the leaves as indicating their age, the presence of "tip" (unexpanded leaf-bud), and the taste of the infusion.

Theobromine, or dimethylxanthine, $C_5H_2(CH_3)_2N_4O_2$, and its isomer theophylline are closely allied to caffeine, but occur in small proportion only

The following are the most important drugs containing caffeine, theobromine or other alkaloid belonging to the purine group:—

Tea, the leaves of *Thea sinensis*, containing caffeine (1 to 5 per cent.), theobromine, and theophylline.

Coffee, the seeds of *Coffea arabica* Linn., family Rubiaceæ, containing caffeine (0 4 to 1 5 per cent.)

Cola Seeds, the seeds of *Cola vera* Schumann, family Sterculiaceæ, containing caffeine (2 to 2 5 per cent.) and traces of theobromine

Maté, the leaves of *Ilex paraguensis* St. Hilaire, family Aquifoliaceæ, containing caffeine (0 2 to 2 0 per cent)

Guarana, the crushed seeds of ***Paullinia cupana*** Humboldt, Bonpland, and Kunth, family Sapindaceæ, containing caffeine (2·5 to 5 per cent.).

Cocoa, the seeds of ***Theobroma cacao*** Linn., family Sterculiaceæ, containing theobromine (2 per cent.).

Cassina, the leaves of ***Ilex Cassine*** Walter, family Aquifoliaceæ, containing caffeine (1 to 1·65 per cent.).

Adulterations. Tea has been adulterated with foreign leaves, as well as with exhausted tea leaves that have been rolled and dried.

Uses. The chief pharmaceutical use of tea is as a source of caffeine which has a marked stimulant action on the nervous system and heart, and is also diuretic but less powerfully so than theobromine.

Other Drugs described as Teas. *Abyssinian, Arabian* or *African tea* consists of the leaves of ***Catha edulis*** Forskal, family Celastraceæ; it contains the alkaloids d-nor-isoephedrine (cathine), cathinine and cathidine.

Bush tea is the leaves of various species of ***Cyclopia***, family Leguminosæ; it is used in S. Africa.

Marsh tea is the leaves of ***Ledum palustre*** Linn., family Ericaceæ.

Kaporie tea is the leaves of ***Epilobium angustifolium*** Linn., family Onagraceæ.

Mexican tea is ***Chenopodium ambrosioides*** Linn., family Chenopodiaceæ.

Kutai tea is the leaves of ***Vaccinium myrtillus*** Linn., family Ericaceæ.

None of these contains caffeine.

SQUILL, Scilla, Bulbus Scillæ, Radix Scillæ

Sources. Squill consists of the sliced and dried scale-leaves from the bulb [illegible] plant indigenous to the [illegible] and frequently [illegible] most ancient of [illegible] well known to the Greeks and Romans; [illegible] o European medicine by the Arabian [illegible]

[illegible] tunicated bulb, often weighing 2 kg. or [illegible] mbedded in the sandy ground. Two varieties are known, the white and the red; the former is collected largely in Sicily and Malta and is preferred in England, the latter is collected in Algeria and Cyprus, and is the variety used medicinally in France.

Collection and Preparation. The bulbs, which are 18 to 20 cm. high and 12 to 15 cm. in diameter, are lifted toward the end of August, the fibrous [illegible] slices about 1 cm. thick, which are dried in the sun or sometimes by artificial heat.

Description. The drug consists of slices which are arcuate and concavo-convex, being about 3 to 6 cm. long and 3 to 8 mm. wide and thick at the middle point. They are somewhat translucent, yellowish- [illegible] tissue. The odour is very slight and the taste is disagreeable, bitter and acrid. Occasionally the entire fresh bulbs are imported; these can be successfully stored in a refrigerator.

Histology. The epidermis consists of axially elongated quadrangular or polygonal tabular cells about 30µ wide, 35µ deep and 80 to 180µ long in the upper, and 50µ wide, 50µ deep and 150 to 300µ long in the lower epidermis; nearly circular stomata, about 30µ × 40µ, are present on the lower (outer) surface in very small numbers and also occur very rarely on the upper (inner) surface. The mesophyll consists of polyhedral paren-

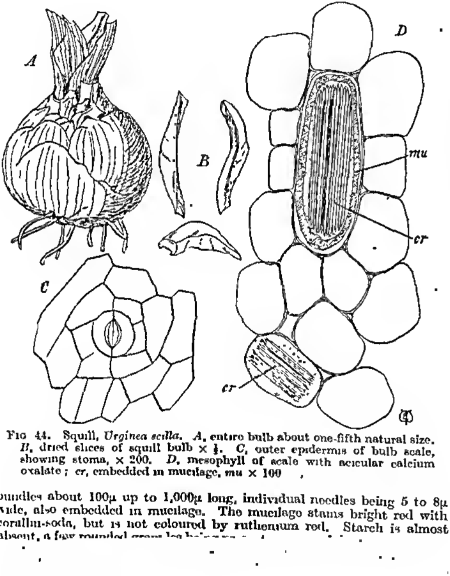


FIG 44. Squill, *Urginea scilla*. *A*, entire bulb about one-fifth natural size. *B*, dried slices of squill bulb × ½. *C*, outer epidermis of bulb scale, showing stoma, × 200. *D*, mesophyll of scale with acicular calcium oxalate; *cr*, embedded in mucilage, *mu* × 100

bundles about 100µ up to 1,000µ long, individual needles being 5 to 8µ wide, also embedded in mucilage. The mucilage stains bright red with corallin-soda, but is not coloured by ruthenium red. Starch is almost absent, a few rounded grains ...

Constituents. ...
an amorphous ...
The drug ...
mucilage, ...

alcohol, probably identical with tritiein and irisin), and calcium oxalate in bundles of long acicular crystals; the latter easily penetrate the skin when the bulbs are handled, and give rise to excessive irritation This irritation has, however, also been referred to a volatile or unstable substance present in the drug.

Uses. Squill closely resembles digitalis in increasing the vigour and diminishing the frequency of cardiac action; it is also a powerful expectorant, and is much used in chronic bronchitis and for coughs generally In large doses it produces emesis.

Storage. Powdered squill is very hygroscopic and rapidly becomes a rubbery mass when exposed to moist air; it can be kept in good

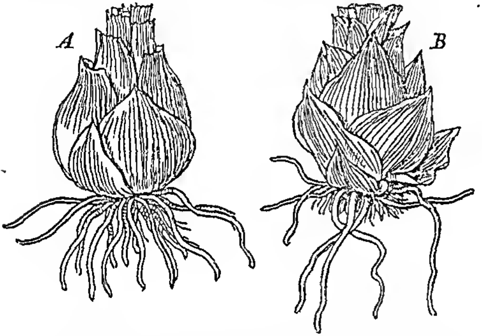


FIG. 45. Indian squill. *A*, tunicated bulb of *Urginea indica* Kunth. *B*, scaly bulb of *Scilla indica* Roxb. (both from Wight's "Icones").

condition by storage in a bottle with a hollow stopper containing quick-lime which maintains a desiccated atmosphere.

URGINEA. Indian Squill, Urginea

Source. Indian squill is obtained from *Urginea indica* Kunth, a plant resembling European squill but producing a smaller, tunicated bulb; it is found in sandy soil near the sea throughout India. The bulbs are collected soon after the plants have flowered, divested of their dry, outer, membranous coats, cut into slices and dried.

Description. The drug occurs in curved or sickle-shaped strips, either separated or connected, several together, to a portion of the shortened axis; usually 1 to 5 cm. long and 5 to 10 mm. wide; yellowish-white, fleshy, often longitudinally ribbed; tough when slightly moist but brittle and pulverisable when dry; taste bitter and acrid. See Fig. 45 *A*.

Histology. The structure of urginea generally resembles that of squill, but the bundles of needles of calcium oxalate are not embedded in mucilage. Masses of dried mucilage, each of which nearly fills the cell

containing it, occur in most of the other cells of the mesophyll; the mucilage stains red with corallin soda.

Constituents. Indian squill has not yet been thoroughly examined; in all probability the chief constituents are similar to those of *Urginea Scilla*.

Uses. Used in India and the Eastern Colonies in the place of European squill.

Substitute. The bulbs of *Scilla indica* Roxb., which are scaly bulbs, are commonly sold in the Indian bazaars in admixture with those of *Urginea indica* Kunth. See Fig. 45 *B*.

CHAPTER IX

FLOWERS

In a commercial sense the term flowers is used to include a number of inflorescences in addition to flowers as defined botanically. There are also several drugs which consist of parts of flowers and are named accordingly. All these structures are grouped for the purpose of pharmacognosy under the heading flowers.

Convallaria flowers (lily of the valley) are actually simple *racemose* inflorescences, other examples of which are found in lobelia, aconite and foxglove. In all these examples there is an elongated axis or *rachis*, bearing flowers on *pedicels*, which arise in the axils of the leaves, usually termed *bracts*, the youngest bracts and flowers being nearest to the apex or growing point of the rachis. Other types of racemose inflorescence are the capitula of chamomile, insect flower, santonica or wormseed, etc., in which the axis is shortened to form a disc-shaped structure, the *receptacle*, upon which the flowers or *florets* are arranged in crossing spiral lines, the youngest florets being at the centre where is the apex of the receptacle. Frequently in a *capitulum*, the outermost florets possess a corolla elongated to form a strap or ligule, as in chamomile and insect flowers, such florets being termed *ligulate* florets and forming collectively the *ray* of the capitulum; the remaining florets have a tubular corolla and constitute the *disc* of the inflorescence. In other instances, such as the capitulum of santonica, the florets are all tubular. The bracts of a capitulum are partly grouped as an *involucre* below the inflorescence, when they are barren, *i.e.*, having no flowers in their axils, and they partly occur with the florets as delicate scale-like structures named *paleæ*, a floret arising in the axil of each palea. Paleæ are not always present and their occurrence or absence afford useful means of distinction between different capitula.

An *umbel* having the youngest flower in the centre is an example of a racemose inflorescence in which the internodes of the main axis have not developed and the pedicels of the flowers appear to arise from a common point. Umbels are most usually compound, that is, a number of small umbels arise from the ends of stems which are themselves arranged in an umbel; this type of inflorescence occurs in caraway, dill, fennel, etc. Another compound inflorescence is found in the drug kousso, which is an example of a *panicle* and consists of a number of small racemes arranged in a racemose manner upon a primary axis. Cloves are also arranged in panicles, but the arrangement of the branches is opposite and decussate instead of alternate as in kousso.

A *cymose* inflorescence is formed when the axis ends in a flower and further flowers must arise upon branches borne laterally upon the first axis. The oldest flower is therefore found at the centre of a cymose inflorescence. Stramonium has a *dichasial* cyme because two lateral axes arise below each flower as it is formed. In belladonna, one lateral branch only is formed each time, first on one side and then on the

other, giving rise to a monochasial cyme, termed a *cincinnus*. In the elder, *Sambucus nigra*, several branches arise below the terminal flower and produce a *polychasial* cyme.

The inflorescences of lavender, rosemary and other labiate plants are good examples of *mixed* inflorescences, where a number of small cymes are arranged upon a parent axis in a racemose manner.

Individual flowers have the general arrangement of parts found in a leaf-bud, the short axis with undeveloped internodes being termed the *thalamus* or *torus*, and the floral leaves are generally arranged in whorls named from below upwards, the calyx, corolla androecium and gynoecium or pistil. The individual members of the calyx are *sepals* which are usually green and most nearly approach foliage leaves in their general character. The *petals* of the corolla are often white or brightly coloured and of a delicate texture with slender veins and a velvety upper surface. The androecium consists of *stamens*, each of which has a stalk-like portion or *filament* and a head or *anther* within which the *pollen* is found. The members of the gynoecium are termed *carpels* and are leaves greatly modified to form one or more closed chambers, called the *ovaries*, within which the *ovules* are borne upon a *placenta*; the ovary is surmounted by a style or styles and stigma.

Amongst common drugs, saffron and corn-silk consist of styles and stigmas only, red poppy, red rose and marigold of petals only; elder flowers of petals and stamens.

Collection and Drying. Collection of flowers must always be made in fine, dry weather, because petals which are damp when gathered become badly discoloured during drying. Since flowers must be obtained in good condition, they must be gathered at precisely the correct time and consequently the process of collection may extend over several days or in some cases weeks, so that the flowers may be taken as they come to the proper condition upon the inflorescences. The collection is usually made by picking or cutting the flowers by hand, but for some types of flower, such as insect flowers and other capitula, a special appliance is sometimes used.

Cloves, red rose and wormseed are collected when in bud; arnica, chamomile, elder and insect flowers when just fully expanded, while kousso is collected after pollination and fertilisation.

Drying must be done carefully and rapidly, otherwise the colours are spoilt. Most flowers and floral members contain volatile oil, upon which their pharmaceutical value depends and are therefore dried at as low a temperature as possible. Large airy lofts or barns are often used and the flowers are spread on canvas stretched on frames so that air may get to both sides of the flowers. The flowers or petals are put in a thin layer on the canvas and are turned two or three times a day, the drying being effected at ordinary temperatures and usually in the dark. The drying room should be without windows because light tends to bleach the delicate colours of petals. In an unfavourable climate, petals are sometimes dried by gentle artificial heat in special drying sheds similar to those used for drying leaves.

Flowers and floral parts should be packed and stored in air-tight containers and kept in a cool place away from the light.

Histology. The members of the floral whorls, which are usually regarded as foliar structures, are all modified to adapt them to purposes of reproduction and the amount of modification steadily increases from calyx to gynæcium. The **sepals** commonly possess upper and lower (inner and outer) epidermises which closely resemble those of the leaves and stem of the same plant. Stomata are present and frequently also covering trichomes; when glandular trichomes are present they are often of diagnostic value. The mesophyll is usually undifferentiated and resembles the spongy tissue of a foliage leaf, chloroplasts being present in most of the cells **Petals** are much more specialised than the sepals. The upper or inner epidermis is frequently papillose, a condition which gives the velvety appearance to petals. These papillæ are easily recognised both in surface view and in section and constitute a very useful anatomical character of flowers. The lower or outer epidermis is without papillæ and stomata are often present, but in small numbers. The mesophyll is thin and frequently consists of three or four rows of cells with large intercellular spaces; it is not differentiated. The colour of petals is due either to a coloured cell-sap or to coloured plastids. Blue and red colours result from the presence of anthocyanins dissolved in the cell-sap and they give red colours with acids and blue or green with alkalies, as in lavender and red rose. Yellow pigments may be dissolved in the sap, when they are flavonol derivatives, as in *Genista*, *Antirrhinum* and *Narcissus*; more commonly yellows are due to the presence of plastids containing carotin and xanthophyll, as in arnica and hyoscyamus. Typical glands and trichomes are also common on petals. The vascular system is much reduced, the delicate veins usually consisting of a few very narrow spiral vessels. The anthers of the **stamens** provide two of the most easily identified structures found in flowers. These are the fibrous layer or endothecium of the pollen sacs and the pollen-grains. The epidermis of the anther may also be characteristic as also are any trichomes, such as those present in lobelia. The endothecium is developed as a hypodermis and consists of a single layer near the dehiscence line, but frequently becomes gradually wider until it is several cells thick near the connective. The cells are parenchymatous and each contains a spiral band of lignified thickening, appearing in a transverse section of the anther as bars in the anticlinical plane; in surface view the [illegible]

being the size, shape, sculpturing and markings of the exine, the germinal furrows and the germ-pores. The germinal furrows are narrow lanceolate areas where the exine is thinner and their function is to accommodate the [illegible] changes in humidity; in the [illegible] ted. Pollen grains of saffron, [illegible] spherical and with a smooth exine; those of compositous plants are spherical, usually with a spiny exine and have three germ pores; the pollen grains of belladonna are spherical, the exine is marked with rows of fine pits and shows three [illegible] gloves the [illegible] outline [illegible], affords useful histological characters chiefly in the form, size and arrangement of the papillæ of the stigma.

Classification of Flowers

Stigmas.	Saffron.	
Petals.	Red Poppy.	Red Rose.

Corolla.	Marigold.
Corolla and stamens.	Elder Flowers
Flower-buds.	Cloves.
Inflorescences	
Raceme.	Lily of the Valley.
Panicle	Kousso.
Capitula.	Chamomile. Arnica. Insect Flowers. Wormseed. Coltsfoot.

SAFFRON. **Crocus, Hay Saffron**

Sources and History. Saffron consists of the dried stigmas and the top of the style of the saffron crocus, *Crocus sativus* Linn., family Iridaceæ. It has been used since very early times as a medicine, a spice and a dye by the Egyptians, Jews, Greeks and Romans, and the plant has been under cultivation for so many centuries that its original habitat is doubtful. It is thought to be indigenous to Greece, Asia Minor and Persia, in which countries it grows wild. At the present time Spain produces the bulk of European saffron, smaller amounts come from France, Greece and Persia.

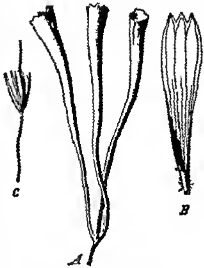


FIG. 46 *A*, trifid stigma of Saffron with a portion of the style, × 2 *B*, Calendula floret, × 1½. *C*, Safflower floret, × 1·5. (Vogl.)

Cultivation, Collection and Preparation. The ground is carefully prepared by ploughing and manuring during April, May and June, and in July the corms are planted in rows about 20 cm apart and at a depth of about 10 cm. Four or five such rows are planted and then a deep wide furrow is made, and beyond that another wide ridge is planted with corms, and so on. Some kind of corn is usually grown in the furrows, which remain as pathways for the saffron collectors after the harvesting of the corn. The plants, from which the saffron is harvested each autumn, stand in the field for about four years, after which they are dug up and the best corms are reserved for replanting. The field is sown with corn after clearing, and when it is replanted the ridges are made in fresh places. The collection is made about sunrise in fine weather during September and November, usually by women and children The flowers are put into baskets and carried to the house, where the stigmas are removed and the corollas rejected. About 500 gm. of the stigmas are put on to a sieve of 30 to 35 cm. diameter, which is supported at a height of about 50 cm above a small fire of wood-charcoal. The drying takes thirty to forty-five minutes, the saffron being turned over every twenty minutes; when dry it is brittle and breaks easily when handled. About 60,000 flowers are required to produce 500 gm. of dry saffron.

Description. Hay saffron forms a loosely matted mass of dark, reddish-brown, flattened stigmas with a strong, characteristic odour and bitterish taste. When fresh it is unctuous to the touch and glossy, but after keeping, it becomes dull and brittle.

Thrown on the surface of water the dry stigmas rapidly expand, and the water surrounding them slowly assumes a deep yellow colour. The colour imparted to 50 ml. of water by 0·1 gm. of saffron is equivalent to the tint obtained by dissolving 0·275 gm. of chromic anhydride in 50 ml. of water. Each stigma is about 25 mm. in length, and has the shape of a long tube, narrow at the base, where it joins the style, but broadening towards the upper extremity, where it is slit on the inner side. The lips of the tube are irregularly notched and the margin is papillose. The stigmas are either single or attached in threes to a short portion of the pale yellow style. If a little powdered saffron is sprinkled on the surface of concentrated sulphuric acid each particle will impart to the acid a deep blue colour easily seen under a microscope.

Constituents. Saffron contains a trace of volatile oil, a bitter principle (picrocrocin), a red colouring matter (polychroite; also called crocin), a colourless, crystalline, non-reducing substance, and a crystalline hydrocarbon.

Polychroite (or crocin) appears to be a mixture of glycosides which yield by the action of cold dilute solution of potassium hydroxide (Karrer, 1927), *β-crocetin* in reddish crystals, *γ-crocetin*, also in reddish crystals and, by acidifying the mother-liquor, *α-crocetin* in bluish-red crystals. All these crocetins, as well as the crocin itself, give the blue reaction with concentrated sulphuric acid, a reaction that is also yielded by carotin.

Substitutes and Adulterants. Owing to its high price, saffron has always been subject to adulteration. The substances used may be grouped in three categories, viz., (*a*) substitution of other materials which have some external resemblance to saffron; (*b*) exhausted saffron recoloured by dyes; (*c*) substances added to saffron in order to increase its weight.

(*a*) Materials used as **substitutes** may be mixed with saffron or supplied in place of saffron, the following have been used: *Styles* of the saffron crocus, which are yellowish, slender and unbranched; *stamens* and *strips of the corolla* of the saffron crocus; ligulate corollas of florets of the marigold, *Calendula officinalis*, which are often coloured with methyl orange and are sometimes known as feminell or Chinese safflower; ligulate florets of safflower, *Carthamus tinctorius* Linn., often found in the cake saffron of commerce; slender stems and roots of some monocotyledons (*e.g.*, *Carex*), coloured artificially.

(*b*) **Recoloration** of exhausted saffron is effected with logwood, Brazil wood, aniline dyes and other synthetic pigments. Most of these can be detected by the colour imparted to water, which is usually red, pink or orange instead of yellow (see above).

(*c*) **Weighting.** Saffron is sometimes weighted by treatment with mineral or vegetable oil, which also improves the appearance of the drug; such saffron leaves a greasy stain on paper. Other methods of weighting are to make use of glycerin, ammonium nitrate and other substances soluble in water, but leaving no ash on incineration. A determination of the aqueous extract of a sample of saffron will reveal the presence of any such soluble matters. The aqueous extract of genuine saffron is about 58 per cent., calculated on the drug dried at 100°.

Uses. Saffron is chiefly employed as a colouring agent, but has also been regarded as stimulant antispasmodic, and emmenagogue.

Note. Cape Saffron, now seldom imported, consists of the flowers of the shrub, *Lyperia atropurpūrea*, Bentham, family Scrophulariaceæ, a native of South Africa; it contains a yellow colouring matter, but could scarcely be mistaken for saffron.

Cake saffron ("croci placentæ," "crocus in placenta") commonly consists of safflower florets made into cakes with an adhesive sugary substance. The structure of the florets is easily seen after soaking in water.

RED POPPY PETALS. **Petala Rhœados, Flores Rhœados**

Source, etc. The red or field poppy, *Papaver Rhœas* Linn., family Papaveraceæ, is a common herb, doubtfully indigenous to England, but abundant in cornfields and waste places throughout Europe and long used as a medicine. It is the commonest British poppy (see Fig 47), and is distinguished by its scarlet petals and glabrous obovate fruit, about as long as broad.

The long-headed poppy, *P. dubium* Linn., is also common, but is generally smaller, more slender, and possesses a capsule often twice as long as it is broad.

Collection. In England, the petals are collected during the end of June and the beginning of July, usually by women and children who put the petals in a bag suspended round the neck so as to leave both hands free. The filled bags are packed in hampers or crates and are dispatched the same day to the wholesalers, who prepare galenicals from the fresh petals. If the petals are to be dried, they are spread in thin layers on canvas trays in warm air or on a sieve placed over a stove. The drying must be done rapidly.

Description. The two hairy sepals of the bud fall off as the four delicate crumpled petals expand. The latter are of a bright scarlet colour, with a short, dark violet claw; they are smooth and shining above, about 5 cm. wide and, broadly elliptical, with an entire margin. They have, when fresh, an unpleasant heavy odour and slightly bitter taste. By drying, the bright scarlet colour changes to a dingy violet. The petals are mostly used on account of the colouring matter they contain, and are then employed in the fresh state.

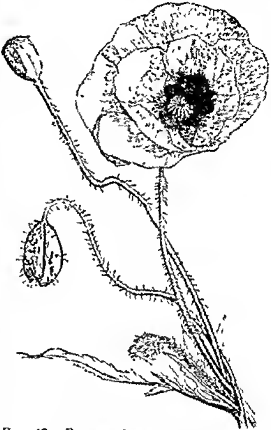


FIG 47 *Papaver Rhœas*, L Flower, fruit and flower-bud. (After Lindley.)

The numerous veins run from the base towards the margin and anastomose freely by very fine branches; the fine ends of the veins unite by arches, leaving a space about 0 15 to 0 25 mm. wide destitute of veins just within the margin of the petal.

Constituents. The colouring matter of the petals consists of a mixture of mekocyanin, the glucoside of cyanidin, probably present in combination with an acid (see p. 146), with a smaller quantity of a substance resembling the glucoside of delphinidin It is doubtful whether they contain either morphine or meconic acid

The petals of *P. dubium* contain a toxic alkaloid, aporeine, resembling thebaine in its action, and should therefore be rejected

Use. Red poppy petals are employed chiefly as a colouring agent.

RED-ROSE PETALS. Petala Rosæ Gallicæ

Source, etc. The red or Provins rose, *Rosa gallica* Linn., family Rosaceæ, is probably indigenous to southern Europe, but has been cultivated as a garden plant in numerous varieties everywhere. For medicinal use the red rose is grown in England (Oxfordshire, Derbyshire, etc.), in the south of France, near Hamburg, etc.

Collection. The cone-shaped mass of petals is cut away from the calyx of each flower bud just before expansion would normally occur. They are carefully dried over a stove at a temperature of about 35° C. and protected from the light. If dried in the air without stove heat, eggs of insects are apt to be laid in the petals. The drug is stored in well-closed vessels away from the light. For the preparation of *confection of roses* the fresh petals are used.

Description. The drug consists of small cone-shaped masses of petals about 2 cm. high and 0·9 to 1·3 cm. wide at the base. The petals are obovate-triangular to ab-cordate, with a velvety surface; they are deep purplish red and paler towards the base where the colour is yellowish. They have a delicate rose-like aroma and an astringent taste. The red colour is changed to deep yellowish-red by acids, to green by alkalies, and deep blue by salts of iron.

Constituents. Red-rose petals contain a trace of volatile oil, gallic acid and tannin. The colour is due to the glucoside cyanin (micro-crystalline, dark brown powder, 2 per cent.), which is probably combined with an acid; when present as a potassium salt (as in cornflowers) cyanin produces a dark blue colour. The crystalline yellow substance obtained by Naylor and Chappel (1904) was probably a decomposition product of cyanin.

Substitutes. Red-rose petals should have attached a portion of the paler base of the petal. Artificially coloured petals may be recognised by their uniform dark reddish colour.

Uses. The petals are chiefly used medicinally, in the form of acid infusion, as an agreeable astringent vehicle or as a colouring agent.

Allied Drugs. *Rosa centifolia* Linn., largely cultivated as a garden plant, has pale red or pink petals; formerly official for the production of rose water.

Rosa damascena Linn., largely cultivated in European Turkey, Bulgaria, the south of France, etc., yields otto of rose and is the rose from which rose water is officially prepared.

CALENDULA. Flores Calendulæ, Marigold Florets

[illegible] is [illegible] abo[illegible] numerous barren disc-florets and one or more rows of fertile ligulate ray-florets.

Collection. The drug is collected chiefly during August when the flowers are most abundant. The ligulate corollas are removed from the capitula, spread on canvas trays and dried in an airy room.

Description. The drug consists almost entirely of the ligulate corollas of the ray-florets, about 3 cm. in length. The limb or strap of the corolla is 1·2 to 3·7 cm. long and 3·5 to 6 mm. broad at the widest part; it is oblanceolate and is terminated by three, or sometimes two or four, acute teeth; it has four (sometimes five to seven) principal veins which are joined by arches at the apex. The tube of the corolla is 1·5 to 2 mm. long and bears characteristic trichomes externally. The remains of the style [illegible]

Constituents. Calendula contains traces of volatile oil, a bitter principle, and calendulin, the latter being a tasteless substance ... (Geiger, 1818).

Uses. Calend... water as ... blood.

ELDER FLOWERS. Flores Sambuci

Sources. The ... is indigenous an...

FIG 48. *Sambucus nigra* L. 1, Inflorescence and leaves. 2, Corolla and stamens seen from above. 3, The same seen from below. 4, Vertical section of the ovary. 5, Group of fruits. 6, Transverse section of a berry. (After Bentley and Trimen.)

whole of central and southern Europe. It flowers in the early summer, producing large polychasial cymes, about 15 cm. in diameter ... white flowers. The entire inflorescences are ... remain in heaps for a few hours ... and the corolla ... an... salt ... of the fresh flow... fragrance. Either fresh or pick... for the preparation of elder-flower water, but that ... from the fresh flowers has an unpleasant odour, which it is said to lose when redistilled after having been kept for some weeks.

Description. During drying the corollas shrivel, so that details of their structure are obscured and the drug consists of small crumpled masses about 1.5 to 3 mm. in diameter, mixed with a few small stalks and flower-

buds; the whole is pale brownish-yellow, with a pleasant odour and a bitter taste. The fresh corollas are rotate, about 4 to 5 mm. in diameter, with five ovate lobes and a very short tube, into which five stamens with short filaments and yellow anthers are inserted. The ovary is inferior, three-celled and surmounted by five small, green calyx teeth.

Constituents. Elder flowers contain about 0·3 per cent. of volatile oil, which may be obtained by distilling the fresh flowers with water, saturating the distillate with salt and shaking it with ether; on evaporating the ethereal solution the oil is left as a yellowish buttery mass. They also contain rutin, a yellow, crystalline substance, found also in *Eschscholtzia* flowers.

Substitutes, etc. Some commercial samples of elder flowers consist of the dried cymes freed from the larger stems of the floral axis and they consequently contain much small stalk as well as the ovaries and calyces of the flowers and some immature fruits. The flowers of various small composite plants (*e.g.*, *Achillea Millefolium* Linn., family Compositæ) are sa[illegible] The latter can be eas[illegible] which, however, is a comparatively rare plant, are distinguished by their dark red anthers.

Use. *The fresh flowers, infused in melted lard, yield elder-flower* ointment. The dried flowers are used usually in the form of an infusion as a diuretic and sudorific.

Notes. The fresh ripe fruits contain tyrosin; the leaves and bark an[illegible] also contain the [illegible] henylglycollic [illegible] digesting the leaves in a melted mixture of lard and suet.

CLOVES. Caryophylli. Caryophyllum

Sources and History. The clove tree, *Eugenia caryophyllata* (Thunb.) family Myrtaceæ, is a handsome evergreen tree and a native of the Molucca Islands, where, as well as on the neighbouring islands, it was formerly extensively cultivated.

Although the spice was known in China about 250 B.C. and in Europe in the fourth century, the Clove Islands were not discovered till 1504. They passed into the hands of the Portuguese and then into those of the Dutch, who unsuccessfully attempted to monopolise the trade in cloves and confine the tree to the Moluccas. The French, in 1770, succeeded in introducing the plant into Mauritius and Réunion, whence it was brought to Cayenne and to Zanzibar. On the latter island and its neighbour, Pemba, the clove tree is now extensively cultivated, and these two islands furnish the bulk of the world's supply, the remainder being obtained from Penang, Amboyna, Madagascar, etc.

Cultivation. Plants are raised from seed spaced about 25 cm. apart and screened from the sun by frames erected about 1 metre above the ground and covered with banana leaves. As the leaves decay more sunlight is automatically admitted until, when about nine months old, the seedlings are strong enough to bear full sunshine. When about 1 metre high the seedling trees are planted out at the beginning of the rainy season, being spread about 6 metres apart. For the first two or three years the trees are shaded by growing bananas amongst them; at the sixth year they begin to bear, yielding 3 or 4 kilos of cloves per tree until about seventy years

old. The trees attain a height of about 9 metres, but in the Moluccas they are topped at about 3 metres for convenience in collecting.

picked by hand or, in the case of the higher ones, are knocked off by bamboos or reached from movable platforms. After separating them from stalks, the buds are spread out on mats made of coco-nut leaves or upon large concrete floors to dry in the sun, a process which takes about three days. During drying they lose about 60 per cent. of their weight and become deep reddish-brown in colour; at night the cloves are taken under cover in sheds The cloves are collected from the mats by pouring them from one to another or they are swept by brooms from the concrete floors and put into baskets. Finally they are packed in sacks, known also as "mats," made of coco-nut leaves. In Zanzibar the collection takes place from September to March.

Cloves dry more quickly on the concrete floors, called barbecues, and have a paler and better colour and command a higher price.

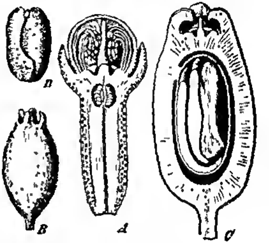


Fig. 49. Clove (*Eugenia caryophyllata*). *A*, clove cut vertically, showing calyx, corolla, stamens, pistil, and ovules; near the margin oil-glands; magnified. *B*, fruit (mother clove), natural size. *C*, the same, cut vertically and magnified. *D*, embryo, natural size. (Luerssen.)

Description. Good cloves are bright reddish-brown, they are plump and heavy and are about 16 to 21 mm. long. The lower stalk-like portion is about 10 to 13 mm. long, 4 mm wide and 2 mm thick, flattened-cylindrical or somewhat four-sided. This stalk is surmounted by four spreading, thick, acute sepals about 3 mm. long, and by the dome-shaped corolla about 5 to 5·5 mm. in diameter, which is formed of four bowl-shaped petals. The stamens are indefinite

ovary is situated in the upper part of the stalk-like part of the clove, the lower eight-tenths of which is solid, though rather spongy near the centre, and is known as an hypanthium. Each loculus is about 3 mm. long and contains about twenty ovules attached to an axile placenta.

hypanthiur

numerous

pressed w

the surface. After removing the corolla, cloves sink when thrown into water. The odour of cloves is strong, spicy and aromatic; the taste is agreeable, warm and aromatic.

Histology ... parenchyma
(sometimes ... in diameter,
having abo... is surrounded

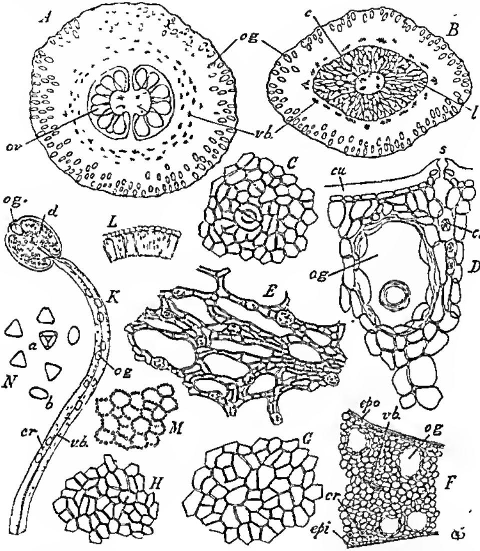


FIG. 50 ... *A*, transverse section of hypa... , transverse section of hypant... lermis of hypanthium, × 200. ... hypanthium, × 200. *E*, transverse section of lacunar region of hypanthium, × 36. *F*, transverse section of a petal, × 65. *G*, outer epidermis of petal, × 200. *H*, inner epidermis of petal, × 200. *K*, stamen, × 15. *L*, epidermis and fibrous layer of anther, × 200 *M*, fibrous layer of anther, surface view, × 200. *N*, pollen, × 200, *a*, showing broad face with markings due to mutual pressure; *b*, showing edge of pollen-grain; *c*, columella; *cr*, cluster crystal of calcium oxalate; *cu*, cuticle; *d*, dehiscence line of anther; *epi*, inner epidermis; *epo*, outer epidermis; *l*, lacuna; *o g.*, oil-gland; *ov*, ovule; *s*, stoma; *v.b.*, vascular bundle.

by a lacunous region of ærenchyma, beyond which is a circle of about twenty to fifty larger vascular strands; externally to these is a wide band of collenchymatous parenchyma containing, especially in the outer part,

numerous ovoid schizo-lysigenous oil glands, each up to about 200 microns long; the epidermis is formed of small tabular cells with straight walls and a thick cuticle and containing numerous stomata of the ranunculaceous type; associated with the vascular bundles are a few thick-walled pericyclic fibres; cluster crystals of calcium oxalate occur throughout the tissues. The *sepals* have an epidermis similar to that of the hypanthium with numerous stomata on the outer surface; the mesophyll is paren- [illegible] a few slender vascular strands, it contains [illegible] cluster crystals of calcium oxalate. The [illegible] cells with straight walls and an undifferentiated mesophyll containing oil glands and cells with cluster crystals of calcium oxalate and traversed by small vascular strands; stomata are absent. Each *stamen* has a filament with a central vascular [illegible]

[illegible]

15 to 20μ in diameter. The tissues of the clove contain neither sclereids nor prisms of calcium oxalate, details which distinguish cloves from clove stalks in which both are present. Starch also is absent from cloves, but present in the fruits, known as Mother Cloves (see below). Trichomes are absent from all parts of the clove.

A 50 per cent. solution of caustic potash reacts with the eugenol in the volatile oil of the oil-glands to give needle-shaped crystals of potassium eugenate and a solution of ferric chloride gives a bluish-black coloration with the tannin present.

Constituents. Cloves contain about 15 to 20 per cent. of volatile oil, a considerable proportion (13 per cent., *Peabody, 1895*) of gallotannic acid, and a colourless, odourless, crystalline substance, caryophyllin. They yield from 5 to 7 per cent. of ash and about 0·25 per cent of acid insoluble ash. Crude fibre from 6·2 to 9 8 per cent.

Uses. Cloves are used as an agreeable aromatic stimulant, antispasmodic, and carminative, properties that are due to the volatile oil they contain

Varieties. *Penang cloves* are large, plump, and of a bright, reddish-brown colour; *Amboyna cloves* are similar but rather smaller; *Zanzibar cloves* are darker in colour, leaner, and smaller still.

Other Products of the Clove Industry

Clove Stalks. These are the slender stems of the inflorescence axis, which shows opposite and decussate branching. The older internodes are up to 1·5 cm. long and 3·5 mm thick and the ultimate pedicels are about 3 mm. long and 1 mm. thick, the small clustered groups of branches are often as much as 3 5 cm. in total length. Externally they are brownish, rough and irregularly wrinkled longitudinally; the fracture is short and the texture dry and woody. They have, when crushed, an aromatic odour and a pungent clove-like taste. They yield about 5 to 7 per cent. of volatile oil, which is less pleasantly aromatic than that of cloves. They occur regularly as an article of commerce and a few are present in most samples of cloves. Crude fibre 13·6 to 18 7 per cent.

Histology. The epidermis resembles that of cloves and in the older

narrow band separated by a cambium from a fairly wide radiate xylem with reticulately thickened vessels; the central pith is surrounded by a

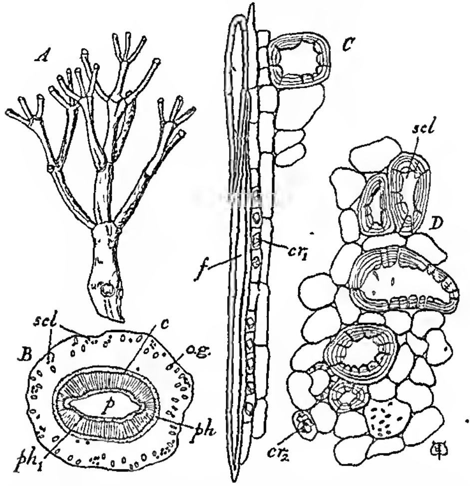


Fig. 51. Clove stalks. *A*, habit sketch showing opposite and decussate arrangement and ultimate pedicels in groups of three (natural size). *B*, diagram of a transverse section × 10. *C*, part of a longitudinal section of the phloem × 250. *D*, part of a transverse section of the cortex × 250. *c*, cambium; cr_1, prism of calcium oxalate; cr_2, cluster of calcium oxalate; *f*, phloem fibre; *o.g.*, oil-gland; *ph*, phloem; ph_1, perimedullary phloem.

perimedullary [illegible] phloem with pericyclic fibres on the inner side; both [illegible] crystals [illegible]

[illegible]

they contain much less volatile oil than [illegible] always contain a few fruits. The fruits can

be detected in powdered cloves because the seeds contain much starch, from which cloves are free

Blown Cloves are expanded flowers from which both corolla and stamens have become detached. The separated corollas and stamens form a product known as *clove dust.*

Exhausted Cloves are cloves from which all or most of the oil has been removed by distillation. They are darker in colour, much shrunken and yield no oil when indented with the thumb-nail.

Oil of Cloves. Oil of cloves is prepared by the steam-distillation of cloves. Steam from a boiler is passed into the lower end of a large cylinder having a perforated false bottom supporting a charge of cloves. The cloves are whole and the iron cylinder is jacketed with some insulating material such as asbestos or diatomite. From the upper end of the cylinder

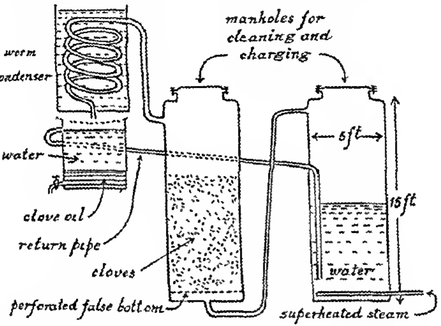


FIG. 52. Diagram of plant for the preparation of oil of cloves.

the vapours are led into a water-cooled worm-condenser and the distillate is received in a tank with a tap at the bottom and an overflow pipe near the top. The overflow pipe is connected with the boiler so that any light oil coming over first is returned with the condensed water to the boiler and passes with the steam through the column of cloves until the oil as a whole has a gravity greater than water and sinks to the bottom of the receiver. The clarified oil is finally drawn off for bottling (see Fig. 52).

The chief constituent of the oil (not less than 85 per cent.) is eugenol, $C_{10}H_{12}O_2$, a colourless liquid with an odour of cloves, boiling at 253°; a terpene (caryophyllene), aceteugenol, α-methylfurfural, dimethylfurfural, methyl salicylate and other bodies are also present. The amount of eugenol present can be approximately determined by shaking a measured quantity of the oil with 5 per cent. solution of potassium hydroxide, with which the eugenol forms a water-soluble compound; the caryophyllene which floats on the surface can be measured by suitable means and deducted from the volume of oil used, the difference being eugenol. Specific gravity 1·047 to 1·065.

Clove oil is largely used for the production of vanillin. It is also used as a dehydrating and clearing agent for microscopical preparations to be mounted in Canada balsam.

LILY OF THE VALLEY FLOWERS. Flores Convallariæ

Sources. The drug consists of the dried inflorescences of *Convallaria majalis* Linn., family Liliaceæ, a small herbaceous perennial, growing in shady woods and thickets throughout Europe and indigenous to England; often cultivated in gardens. The bulk of the drug is collected from wild plants which grow in abundance in some parts of the continent of Europe.

Collection. The flowers are collected just before they are all fully expanded, usually in the month of May. The entire scape with its racemose inflorescence is cut from each plant. The inflorescences are dried rapidly by stove heat and are carefully stored away from light and moisture.

Description. The scapes are up to 20 cm. long and each bears in the upper part a raceme of about six to ten flowers. The scape is about 2 mm. wide at the base and tapers gradually towards the apex. The flowers have a bell-shaped perianth, white when fresh, about 4 to 5 mm long and 4 to 5 mm across the open end, which is furnished with six small recurved teeth; the stamens are six and epipetalous; the superior ovary is trilocular and the ovules are attached to an axile placenta. The fresh flowers have a fragrant perfume, which almost entirely disappears on drying. The dried flowers are shrunken and pale buff coloured becoming darker on keeping, and the drug has a slight agreeable odour and a bitter taste.

Constituents. The chief constituent of lily of the valley is a crystalline cardiac glucoside, convallatoxin, which is more toxic than ouabain; it also contains two crystalline glucosides, convallamarin and convallarin.

Use. Lily of the valley flowers are occasionally used as a cardiac tonic in the place of foxglove.

Note. *Convallaria majalis* has a somewhat slender perennial rhizome, producing each year an aerial shoot having two broadly elliptical leaves and a scape bearing a raceme of flowers. The rhizomes are collected and dried to form the drug Lily of the Valley Root, while the dried leaves form a third commercial drug.

KOUSSO. Cousso, Cusso

Source, etc. The tree yielding this drug, *Brayĕra anthelmintica* Kunth (*Hagenia abyssinica* Willdenow), family Rosaceæ, is a native of north-eastern Africa. It is planted by the natives of Abyssinia near their villages for use as a remedy for intestinal worms, from which they suffer severely. Bruce became acquainted with it in the course of his travels through Africa (about 1770).

The panicles of pistillate flowers are collected after fertilisation and dried. They are packed into cylindrical rolls (hanks) about 30 to 60 cm. [illegible] le stem of [illegible] vers, with [illegible] be mixed. The staminate inflorescences, which are sometimes borne on the same, [illegible]

[illegible] th, and are [illegible] The main [illegible]

FIG. 63 *Brayera anthelmintica* A, flowering branch, three-fourths natural size (after Berg and Schmidt) B and C, staminate flower closed and open, magnified. D, pistillate flower, magnified E, the same, cut longitudinally, magnified b, outer, k, inner whorl of sepals; c, corolla. (Luerssen)

under the lens as a brownish powder adhering to the surface. The flowers are very numerous and shortly stalked. Each bears on its pedicel two rounded bracts, and consists originally of two whorls of greenish sepals, a caducous white corolla, abortive stamens, and two monocarpellary ovaries enclosed in the cup-shaped thalamus. After fertilisation the inner sepals bend over the young fruit and shrivel; the outer grow larger and become deeply veined with purple. Only one of the two ovaries arrives at maturity. In the drug the most conspicuous part of the flower is the outer whorl of reddish, veined sepals; in its centre may be found the inner sepals bending over the immature fruit; the corolla and abortive stamens are seldom present.

Kousso has no marked odour, but possesses a bitter, acrid taste.

Constituents. The most important constituent of kousso is kosotoxin (Leichsenring, 1894), a highly active, amorphous, yellowish substance, of which 0·004 gm. is sufficient to kill a frog. Protokosin and kosidin are inactive, colourless, crystalline substances; α- and β-kosin are inactive,

Kosotoxin is insoluble in water but easily soluble in alcohol, ether, acetone, chloroform, etc., as well as in solutions of alkaline carbonates. Caustic alkalies convert it into kosin. By the action of zinc dust and caustic soda

phloroglucin respectively.

Substitutes, etc. Under the name of "loose kousso" the flowers stripped from the panicles and dried are sometimes imported. They arrive usually in more or less fragmentary condition, and frequently contain a considerable admixture of staminate flowers. These may be easily distinguished by their greenish colour, small outer sepals densely covered with short hairs, and fertile stamens; they are often unexpanded. A standard number of not more than 200 pollen-grains per milligram is used to exclude staminate flowers from powdered kousso.

Use. ... killed by it. ... It is commor ... being swallowed

CHAMOMILE FLOWERS. Flores Anthemidis. Roman Chamomile

Sources and History. Chamomiles are the dried expanded flower-heads of *Anthemis nobilis* Linn., family Compositæ, collected from cultivated plants having double capitula.

century. The name Roman was given to this chamomile by the German physician Joachim (also known as Camerarius) towards the end of the sixteenth century because he noted its abundance in the neighbourhood of Rome. About the same period the German botanist Bock (latinised Tragus) named the plant Chamomilla from two Greek words meaning "apple on the ground" because the plant grows close to the ground and has an odour which was thought to resemble that of apples.

The drug is produced to some extent in the south of England, but more largely in Belgium, France, Saxony and Hungary.

Cultivation. The plant is a small, low-growing perennial with procumbent stems ascending at the tips. The leaves are downy, sessile and pinnatisect with fine, linear segments. It is particularly suitable for cultivation on a stiff loam; extremes of cold and dry heat as well as excess of moisture are harmful to the plants. Each of the old plants is divided into a number of parts which are planted in a nursery in the autumn. In April the rooted cuttings are planted in the field in rows about 60 cm. apart, with 30 cm. between the plants in the rows. The ground is kept free from weeds and the plants are allowed to stand for four years at the end of which the whole field is dug up and a new set of cuttings prepared.

Collection. Flowers are produced abundantly from the second year onwards; collection begins in June and is continued until September. They are usually picked by hand by women and children, care being taken to collect only those capitula which are just fully expanded. They are spread out to dry in thin layers on canvas supports in dry airy sheds or in drying chambers, being careful to screen them from dust; 100 parts of fresh flowers yield about 35 parts of dry. The dried flowers are separated into three grades by sieves, and the smallest size is chiefly used for distilling the volatile oil. The commercial value of the flowers depends upon their size and whiteness, so that care is taken to gather them in fine, dry weather and to transfer them as quickly as possible to the drying sheds. Flowers which are damp when gathered become very dark in colour on drying.

Description. The dried flower-heads, or capitula, are hemispherical 10 to 20 mm. in diameter and white or nearly white in colour, becoming yellowish or buff-coloured when kept. The involucre surrounding each capitulum is almost entirely concealed by the strongly reflexed outer ligulate florets.

The double capitulum of the cultivated plant is derived from the single capitulum of the wild plant. This single capitulum has a single row of white ligulate florets and a central group, or disc, of 200 to 300 yellow tubular florets arranged in closely packed series of crossing spirals upon the conical receptacle. During the development of the double capitulum the majority of the yellow tubular corollas of the disc florets become converted into white ligulate corollas similar to those of the ray florets. The commercial capitula, therefore, consist almost entirely of ligulate florets with usually a few, about ten to twenty, tubular florets near the apex of the receptacle. The conical receptacle itself is about 3 mm. high and 2 mm. wide at the base; it is solid and pithy in texture and bears at its base two or three rows of overlapping bracts forming an involucre surrounding the whole capitulum. The involucral bracts are about 4 to 5 mm. long and 1·5 mm. wide. The remaining surface of the receptacle bears intersecting spiral lines of bracts or paleæ in the axil of each of which a floret is situated. The paleæ are about 3 to 4 mm. long and 1 mm wide The involucral bracts and the paleæ are similar in construction, but the bracts are somewhat coarser and stronger. The bracts and paleæ are oblong-ovate and concave with a blunt apex, a central lanceolate thicker region and a wide scarious margin only one cell thick. On the outer convex surface of each are a few narrow uniseriate trichomes

about 0·7 to 1·0 mm. long, each composed of three to eight very short basal cells and a long terminal cell about 20μ wide; there are also numerous small compositous glandular trichomes each consisting of a short stalk and a head of two or three tiers of two cells each.

Ligulate floret; calyx absent; strap of corolla oblong-lanceolate, 7 to 9 mm long and 2 to 3 mm. wide, tube 1·5 to 2 mm. long, ovary 1 to 2 mm. long and 0·3 to 0·5 mm. wide; the strap terminates in three or sometimes two rounded teeth and has four principal veins, which

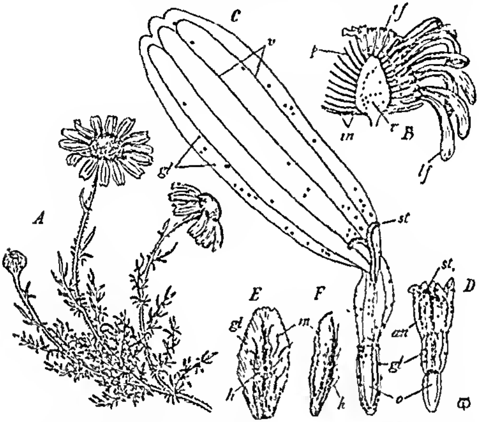


FIG. 54. Chamomile flowers (*Anthemis nobilis*) *A*, habit sketch of a flowering plant (after Lindley). *B*, a flowerhead in longitudinal section × 2·5, florets removed from the left-hand side, so as to show the paleæ. *C*, a ligulate floret × 8. *D*, a tubular floret × 8 *E* and *F*, outer and side views of a palea, both × 3. *an*, anther; *gl*, glandular trichome; *h*, covering trichome; *in*, involucre, *l.f.*, ligulate floret; *m*, membranous margin; *r*, receptacle of the capitulum, *st*, stigma, *t.f*, tubular floret; *v*, vein

unite by arches near the apex of the strap. Andrœcium absent. Ovary inferior, unilocular, style as long as the corolla-tube and bifid at the apex. *Tubular floret* when well developed is about 3 to 5 mm. long; calyx absent; corolla yellow, tubular, with five rounded teeth; stamens five, [illegible] n as in the ligulate floret. [illegible] 'ar trichomes similar to tho[illegible] parts of the florets.

Chamomiles have an aromatic bitter taste and a pleasant, strong aromatic odour.

Constituents. The principal constituents of chamomile flowers are the volatile oil (0·8 to 1·0 per cent.), the bitter principle, anthemic acid and a yellow colouring substance, apigenin (a trihydroxy-flavone) free and in the form of a glucoside.

The volatile oil is blue when freshly distilled, but becomes greenish- or brownish-yellow on keeping; it consists chiefly of the esters of the isomeric acids angelic and tiglic, with isobutyl and amyl alcohols; it also contains the alcohol, anthemol, and a crystalline hydrocarbon, anthemene.

FIG. 55. *Matricaria Chamomilla* L. 1. Upper part of a flowering plant. 2. Vertical section of a capitulum. 3. A fruit. (After Bentley and Trimen.)

Anthemic acid is an intensely bitter, crystalline glucoside easily hydrolysed with total loss of bitterness, prolonged boiling in water being sufficient to produce the reaction. Power and Browning (1914) were unable to isolate anthemic acid and ascribe the bitterness to a dark-coloured amorphous substance.

The flowers also contain a crystalline phytosterolin, taraxasterol, triacontane, i-inositol, dihydroxycinnamic acid, etc., wax, fatty oil, glucose, etc. They yield about 5 per cent. of ash.

Uses. Chamomile flowers possess aromatic, bitter stomachic properties; the oil is occasionally administered in pills as a carminative.

Substitutes, etc. *Single chamomiles* are obtained from wild plants. They

are distinguished by the presence of a single row of white ligulate florets, the remainder being yellow and tubular. This variety is sometimes sold as "Scotch" chamomiles.

Matricaria Chamomilla Linn., German Chamomile. The flower-heads are smaller, single, and have a hollow conical receptacle devoid of paleæ. The chief constituents are volatile oil, salicylic acid, apigenin, umbelliferone methyl ether and an indefinite bitter principle.

Chrysanthemum Parthenium Bernhardi, Feverfew. The cultivated plant has double flowerheads, resembling those of the chamomile. The receptacle is flat; paleæ may be present or absent, according to the variety; if present they are acute.

ARNICA FLOWERS. Flores Arnicæ, Arnicæ Flos

Sources. Arnica flowers are the dried flowerheads of *Arnica montana* Linn., family Compositæ, a small plant with creeping perennial rhizome indigenous to central Europe, and common in the meadows on the lower mountain spurs.

Description. The dried capitula are somewhat ob-conical masses, about 2 cm. in diameter and 1·5 cm. high. Many of the receptacles occur separate and the florets form a loose greyish-yellow mass, in which the much shrivelled corollas are inconspicuous and the bristles of the pappus are the most prominent feature. The receptacles with their involucres form about 33 per cent. by weight of the drug, but in commercial specimens may be as low as 25 per cent.

Receptacle about 3 to 5 5 to 8 mm. in diameter, flat or slightly convex, marked by numerous depressions each surrounded by bristles; surrounded by about twenty to twenty-five involucral bracts arranged in two rows, dark green, linear-lanceolate and pubescent. *Ligulate florets* in a single row of sixteen to twenty; calyx represented by a pappus of numerous bristles each of which is four to five cells in diameter and minutely denticulate on the surface; strap of the corolla about 2 to 3 cm. long and 3 to 5 mm. wide, with three acute teeth at the apex and seven to nine veins, sometimes four to five teeth and up to fifteen veins, which anastomose by arches near the apex, orange-yellow; stamens absent; ovary inferior 5·5 to 7·5 mm. long five-ribbed unilocular, the wall bearing numerous appressed twin trichomes, each composed of two cells which diverge at the tips, style filiform, stigma bifid and spreading. *Tubular floret* has a regular, five-toothed, yellow, tubular corolla about 7 to 8 mm. long; five epipetalous stamens with syngenesious anthers; pappus and ovary as in the ligulate floret. As the ovary of both florets develops into a *fruit*, patches of black phytomelan are formed in the wall. Compositous *glandular trichomes* are present on the corollas of both florets.

Arnica flowers have a pleasant sweet and aromatic odour, and bitter, acrid taste.

Constituents. Arnica flowers contain traces of volatile oil and a bitter principle, arnicin, which has been obtained in minute, yellow, deliquescent crystals The flowers are said to contain more arnicin than the rhizome. The drug also contains tannin, resin, yellow colouring matter and a phytosterin, arnisterin.

Uses. Preparations of arnica flowers applied to the skin appear to increase the activity of the circulation, and the tincture, diluted with water, is used for application to the skin for the treatment of bruises; internally they are stimulant and irritant, but they are now seldom administered.

Substitutes, etc. Some samples of arnica flowers consist of the florets only. The receptacles and involucres are removed because of their

liability to attack by insects, notably by the dipterous fly *Trypeta*

flowers reported to have been mixed
may be mentioned :—

Anthemis tinctoria Linn. ; *fruits without* pappus ; *paleæ on receptacle.*

Calendula officinalis Linn. ; ligulate corolla with four veins ; fruit without pappus.

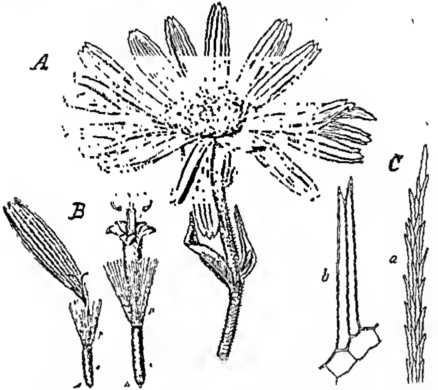


Fig. 56. *Arnica montana* Linn *A*, entire capitulum. *B*, ray-floret and disc-floret ; *a*, anthers ; *o*, ovary , *p*, pappus *C*, bristle of pappus, showing barbs , *b*, twin-hair from the fruit epidermis *A* (*Pharm Journ*) *B* (after Luerssen) *C* (after Bille Gram)

Inula britannica Linn. , ligulate corolla with four veins , pappus not bristly. Arnica from the Italian Alps is frequently derived from *I. britannica.*

Doronicum Pardalianches Linn ; ligulate corolla with four veins ; no pappus.

Taraxacum sp ; *Scorzonera* sp ; all florets with five-toothed ligulate corollas.

INSECT FLOWERS. Flores Pyrethri, Pyrethrum Flowers

Source, etc. Dalmatian insect flowers are the unexpanded flowerheads of *Chrysanthemum cinerariæfolium* Visiani, family Compositæ, a native of Dalmatia, Herzegovina, and Montenegro, and cultivated on the Dalmatian and Istrian Islands, in Japan, California, Spain, Italy, Switzerland, etc. Very large quantities are imported from Japan Experimental

plots at Kew, Wye and Harpenden have yielded encouraging results and the plant is now being cultivated commercially in Suffolk.

The flowerheads retain their insecticidal properties for about six months. The stems and leaves are less active but still sufficiently active to serve for making insecticidal preparations for use on the large scale. Closed flowers have long been considered to be more active than half-closed or open, but recent experiments have shown that capitula with the florets just fully expanded are the most active, though the difference in the toxicity of the flowers collected at different stages of development is not great. Over-blown flowers are much less toxic.

Cultivation and Collection. Seedlings are raised from seed sown in August and September in beds protected by a canvas covering raised about 25 cm. above the level of the soil.
the seedlings are planted out on a rich,
spacing the plants about 30 cm. apart.
May when the first collection is made; a second collection is made in August and September. The plants continue to yield for about six years. The soil between the rows is kept clear of weeds by working it in spring and autumn.

In Dalmatia and other places the flowerheads are collected by hand; in the United States and some parts of the continent of Europe a kind of scoop about 25 cm. wi
form of a coarse comb
flowerheads which are
If it is intended to convert the crop immediately into some kind of extract, it may be reaped by means of a hook. The flowerheads as usually dried by spreading them to a depth of 4 to 5 cm. on cloth stretched on large frames which are exposed to the heat of the sun and are brought under cover at night or when rain or dew is falling. The flowers are turned over two or three times a day and the drying is complete in about three days. In less sunny climates drying is conducted in airy barns and takes about three or four weeks.

Description. The closed flowerheads[1] of commerce are of a dull brownish-yellow or greyish-brown colour and about 5 to 10 mm. in diameter. They are imported either loose, chiefly from Dalmatia, or in strongly compressed masses of flowerheads in all stages of development, chiefly from Japan. The loose flowers are classed as "closed," "half-closed" and "open."

The *receptacle* is 4 to 8 mm. in diameter, flat with a slight central convexity and without paleæ; it is surrounded by an involucre of two or three rows of bracts, which are hairy and lanceolate with a membranous margin. *Ray florets* in a single row of fifteen to twenty-three (rarely over twenty); calyx tubular, membranous, about 1 mm. long; strap of corolla white, about 16 mm. long with three rounded apical teeth, the central one being often more or less suppressed; about seventeen veins, of which five or six are more strongly developed, at the centre of the strap; ovary inferior, about 5 mm. long and five-ribbed; style filiform, stigma bifid. *Disc florets* about 200 to 300, each with a yellow, tubular corolla and five

[1] A sample consisting of closed flowerheads is still rightly regarded as of superior quality, because it ensures the absence of the comparatively inert overblown flowers. In powdered specimens, the presence of more than 2,000 pollen grains per mg. indicates "closed" flowerheads; between 1,000 and 2,000

epipetalous stamens; gynœcium and calyx as in the ligulate floret. *Fruit*, a fine-ribbed cypsela.

Insect flowers possess a bitter, acrid taste; the odour is aromatic, but not strong.

Constituents. Dalmatian insect flowers contain about 0·4 to 2·0 per cent. of two esters to which the insecticidal properties are due, viz., pyrethrin I and pyrethrin II. Pyrethrin I is a viscous oil yielding on

warm-blooded

, about 10 per cent. of moisture, and about 6 to 10 per cent. of yellow ethereal extract. House-flies enclosed in a 100 c.c. well-ventilated vessel, on the walls of which 0·02 gm. of insect powder has been dusted, should be stupefied in two or three minutes (De Waal, 1923). Blow-flies (*Protocalliphora azurea*) are used for testing liquid preparations of insect flowers.

Substitutes, etc. *Chrysanthemum coccineum*, Willdenow (*C. roseum*, Weber et Mohr), a native of the Caucasus and northern Persia, yields the Persian (or Caucasian) insect flowers, which were formerly more commonly used than

practically ceased.

by the dark, nearly

colour of the ray-florets, and by the ten-ribbed fruit. They are said to be

owerheads of

They may be

seven veins

and terminates in three rounded teeth of which the central one is the

may

the

hem

are used to stupefy small insects.

WORMSEED. Santonica, Semen Cinæ, Semen Contra

Sources, etc. Wormseed consists of the unexpanded flowerheads of *Artemisia cina* Berg, family Compositæ. This species grows in enormous quantities in the north-eastern districts of the province of Turkestan. Near the town of Chimkent a factory has been erected, in which large quantities of santonin are produced from the wormseed collected in the vicinity. Comparatively little of the crude drug is now exported.

The plant is small and woody, with numerous erect branches about 40 cm. long, on which very small flowerheads are borne. These are stripped from the stems before they expand, and dried. They are collected in July and August, and brought to Chimkent.

Wormseed has long been used as an anthelmintic; it was employed in Italy under the name of semenzina (diminutive of *semenza* = seed)

word semenzina

is often known;

"semen contra

times.

Description. The flowerheads are of a greenish-yellow colour, but turn brown by drying and keeping. They are from 1·5 to 4 mm. long, elongated

6—2

ovoid in shape, and somewhat angular; their surface is shining and only slightly hairy. A few fragments of leaves and stalks always occur admixed with the flowerheads

The involucre consists of fourteen to twenty, most commonly sixteen, imbricated ovate or lanceolate bracts, each having a distinct keel and bearing on the dorsal surface numerous, glistening compositous glandular trichomes and a very few cottony balance hairs; the midrib branches freely and the veinlets are contorted and frequently anastomose. The

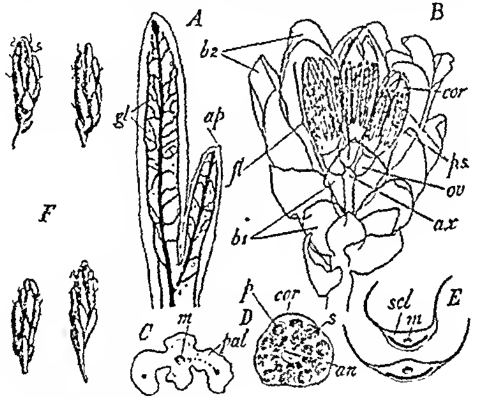


FIG. 57. *Artemisia cina* (Berg) W
foliage leaf, showing the venat-
apiculus; *gl*, gland. *B*, entire
hydrate solution, × 15; *ax*, c
b2, inner bract; *cor*, corolla of a floret; *fl*, floret, *ov*, ovary; *p.s.*, pollen sacs. *C*, transverse section of the foliage leaf, × 30; *m*, midrib; *pal*, palisade tissue. *D*, transverse section of a floret, × 30; *an*, anther; *cor*, corolla; *p*, pollen; *s*, stigma. *E*, transverse sections of two bracts, × 30; *m*, midrib; *scl*, sclerenchyma. *F*, four entire flower-heads, × 8.

bracts enclose about three to five tubular, hermaphrodite florets about 1 mm. long and 0·5 mm. wide, the apices of the five corolla lobes being slightly papillose but not bearing trichomes; compositous glandular trichomes occur on the outer surface of the corolla and ovary. The leaf fragments are linear-lanceolate, about 0·5 to 0·75 mm. wide, with a rounded apex and an apiculus; they have a midrib with numerous lateral veins which anastomose to form a marginal vein at about two-thirds of the distance from the midrib to the margin. The leaves have no covering trichomes, but bear numerous compositous glandular trichomes.

The drug exhales, when crushed, an agreeable, aromatic odour, and possesses a bitter, aromatic, camphoraceous taste.

Constituents. Wormseed contains a volatile oil and two crystalline principles, viz. santonin, to which the anthelmintic property of the drug is due, and artemisin. The santonin attains its maximum (2·3 to 3·6 per cent.—Ehlinger, 1885) in July and August. After flowering it rapidly disappears.

Santonin, $C_{15}H_{18}O_3$, forms colourless, bitter crystals that are very slightly soluble in water but unite with alkalies, forming soluble salts of monobasic santonic acid, $C_{15}H_{20}O_4$. Exposed to light, santonin assumes a yellow colour (photosantonin, chromosantonin); in the intense sunlight of tropical India it is converted into a dark brown resinous mass.

Substitutes, etc. Santonin has also been found in the leaves of a species of *Artemisia* referred to *A. brevifolia* Wallich, which grows in abundance in Kashmir, Kumaon, etc. (0·5 to 1·0 per cent.), in the flowerheads of an undetermined species of *Artemisia* grown in Holland (1·3 per cent.), and in the leaves and flowers of a species of *Artemisia* grown in Scotland, probably *A. maritima* (0·68 per cent.). Its presence in several other species of *Artemisia* has been reported.

Use. Wormseed is now seldom administered, but santonin is often employed as an anthelmintic for round worms which it rapidly expels; it has less effect upon thread worms and no action on tape worms. It produces remarkable disturbances of vision, objects appearing first blue and then yellow, and the absorbed santonin renders the urine intensely yellow if acid or purplish if alkaline.

American wormseed is the fruit of *Chenopodium ambrosioides* Linn.

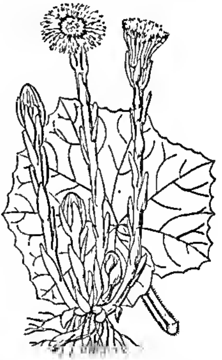


FIG. 58. *Tussilago farfara*—Coltsfoot. Flowering stems and foliage leaf. (After Lindley.)

COLTSFOOT FLOWERS. The flowers of *Tussilago farfara* Linn., family Compositæ. The flowers [illegible] some time before t[illegible] 15 cm. long, with n[illegible]ary, many of the h[illegible] capitula terminal, s[illegible] florets with short, v[illegible] acle flat, naked: fruit cylindrical, tapering towards the base, provided with an abundant pappus of white, simple hairs. Contain mucilage, traces of tannin and a bitter principle. The leaves as well as the flowers are used as a household remedy for chronic coughs.

CHAPTER X

SEEDS

Functionally the seed is the transportation stage in the life of a plant. Structurally a seed is developed from an ovule as a result of growth stimulated by the formation of a zygote from the ovum and of the primary endosperm nucleus from the central fusion nucleus of the embryo-sac. These developments result in the growth of an embryo from the zygote and of food-storage tissues from the embryo-sac and nucellus A seed, therefore, may be recognised as such by considering its origin, its contents and its function and one may formulate a definition from these premises in the following way: *A seed is a plant member derived from a fertilised ovule; it contains an embryo and is constructed so as to facilitate its transportation.*

The origin of the seed from the ovule necessitates the presence of structures in the seed corresponding to the various parts of the ovule and also fixes the general relative disposition of the parts to one another in the seed. A knowledge of the general structure of the fertilised ovule and of the various types of ovule is therefore fundamental to a proper understanding of the structure of seeds.

A fertilised ovule is usually protected externally by one or two coverings or coats from which the testa of the seed is developed. When two coats, outer and inner, are present in a seed they are termed the *testa* and *tegmen* respectively. The term *testa* is also used to indicate the single coat of seeds having only one coat or to signify the two coats considered as one protective covering. In the ovule, the coats are not quite complete at the apex, a small hole, the *micropyle*, being left through which the pollen-tube may pass on its way to the embryo-sac; this micropyle persists in the seed and forms a character of the testa.

Within the coats of an ovule is a mass of parenchymatous tissue known as the nucellus. The nucellus is frequently completely absorbed by the rapidly developing embryo or endosperm and is then represented in the seed by a layer of collapsed cells usually only to be observed in microscopical preparations. In certain seeds, however, such as cardamom and pepper, the nucellus increases in bulk as the seed matures and forms a massive storage-tissue, called the *perisperm*.

Embedded in the nucellus of the ovule is a very large cell, the embryo-sac or megaspore and after fertilisation one finds inside the embryo-sac a zygote, a primary endosperm nucleus and three antipodal cells. The zygote develops by cell-division and becomes the embryo with its one or two or sometimes more cotyledons and a radicle and stem growing point, sometimes developed as a plumule. This development may be so rapid and vigorous that the embryo absorbs the other contents of the embryo-sac and also the contents of the nucellus so that in the seed there is a large embryo surrounded only by the testa, thus forming a *non-endospermic* or *exalbuminous* seed.

In other plants the endosperm nucleus rapidly divides and walls form between the protoplasts resulting in a mass of tissue, called

endosperm, surrounding the embryo which has developed less vigorously than in exalbuminous seeds. The nucellus is absorbed by the developing endosperm so that the ripe seed consists of an embryo embedded in an endosperm, the whole being surrounded by the testa. These are *endospermic* or *albuminous* seeds, containing an embryo surrounded by endosperm.

A third type of development occurs when the endosperm nucleus

surrounding the endosperm. This tissue is the perisperm and the albuminous or endospermic seed which results, consists of an embryo enclosed in an endosperm which is itself surrounded by a perisperm, the whole being enclosed by the testa. A somewhat rare condition in seeds is to find perisperm fully developed, but no endosperm. A good example is the seed of *Agrostemma githago*, the corn cockle, the seeds of which are poisonous and sometimes occur mixed with wheat and other cereals.

On the surface of the testa certain markings can be observed in addition to any mottling or variations in the colouring of the general surface. These markings are the hilum, the raphe, the micropyle and the chalaza, the relative positions of which vary with the type of ovule. The *hilum* is the scar left by the removal of the seed from its funiculus or stalk. The *chalaza* is the position at the base of the nucellus where the vascular strand from the funiculus branches to enter the different parts of the ovule. The four types of ovule arise by the variation in the extent to which ovules are turned upon their stalks.

above the hilum; there is no raphe. This is not a common type of ovule, but is found, for example, in the Piperaceæ and also in the Polygonaceæ, to which rhubarb, dock and buckwheat belong. The most common type of ovule is the *anatropous* one in which the stalk has grown adherent to one side of the ovule and has also grown so rapidly as to completely invert the ovule on its stalk, thus bringing

strand is known as the *raphe*. In most common seeds, therefore, the raphe and chalaza can be observed as markings on the testa and the micropyle is found adjacent to the hilum; examples are seeds of flax (linseed) and almond. Sometimes the rotation of the ovule on its stalk is through an angle of 90 degrees instead of 180 degrees as in the anatropous ovule. When this more limited turning occurs the ovule is termed *amphitropous*. In such ovules the nucellus is straight with its axis at right angles to the direction of the stalk, which enters the ovule at the middle of one side. There is a short raphe as far as the chalaza at one end of the nucellus; at the other end is the micropyle. In this type, therefore, the hilum, chalaza and micropyle are widely separated; an example is the seed of colchicum. The fourth type of

ovule has a curved nucellus produced by a rapid growth of one side of the nucellus and of the coats on the same side, development on the other side being almost arrested. As a result the micropyle is brought adjacent to the chalaza as well as the hilum; there is no raphe. Examples of this type are stramonium, henbane and other solanaceous seeds, they are developed from *campylotropous* ovules.

During the formation of the seed from the fertilised ovule, there frequently arise additional growths outside the integuments or developed from the integuments. According to the origin and nature of the new growths different names are given to them. An *aril* is a fleshy covering arising from the hilum and almost completely enveloping the seed; examples are the seed of yew, *Taxus baccata*, and seeds of the Nymphaceæ. A plume of hairs arising from the hilar end of a seed as in the willow is also sometimes described as a type of aril. An *arillode* is a covering similar to an aril, but arising from the micropylar edge as in Cardamom and Euonymus. A *caruncle* is a localised fleshy growth arising from the micropyle as in seeds of the Euphorbiaceæ, such as castor oil and croton. A *strophiole* is a wing-like or barrel-shaped outgrowth along the line of the raphe, due to an increase in the amount of parenchyma around the vascular strand of the raphe; such a growth is found in the seed of colchicum. A *wing* is an extension of the testa in the form of a membranous fold as in the seed of honesty, and to a very slight extent at the base of the strophanthus seed. A *plume of hairs* is sometimes formed as an outgrowth from the summit of a seed as in the Apocynaceæ and the Asclepiadaceæ, to both of which families many plants used medicinally belong.

All seeds contain reserve foods for the nourishment of the embryo during germination. These foods may be present in the endosperm or the perisperm or in both, or they may be stored in the embryo itself either in the cotyledons or in the axis (as in the Brazil nut) Some- [illegible] cotyledons. [illegible] rbohydrates [illegible] and oxygen, and proteins which supply nitrogen, sulphur and phosphorus in addition to the other three eleme[illegible] starch; others are cellulose, [illegible] sugars, fixed oils and proteins a[illegible] the celluloses are present as heavily thickened cell walls. This gives rise to starchy or farinaceous seeds, such as wheat and calabar bean, oily seeds, such as linseed and the umbelliferous seeds, and very hard horny seeds such as nux vomica, ignatius bean and date stones.

Histology. The most characteristic histological features of seeds are found in the structure of the seed coats. Often a seed has one coat only as in nux vomica, strophanthus, belladonna, henbane, stramonium, almond, calabar bean and the plantains. In other seeds two coats are [illegible]tards. When two coats are [illegible] the limits of the coats and [illegible]levelopment from the coats [illegible] for a cuticularised layer [illegible] or will mark the cuticular surfaces of the epidermises of the inner and outer coats where they are in contact.

In the testa of most seeds **four different layers** can usually be found, though sometimes two or even three characters may be combined in one layer. The four layers are: **(1) The epidermis, (2)** the pigment layer, (3) the sclerenchymatous layer, **(4) the nutrient layer.** The **epidermis** is variously developed in different seeds r

(*a*) A *palisade* layer, which consists of

prisms, the length being from three tc

s and

denly

; very

thick and usually cellulosic. In colocynth the palisade epidermis consists of cells with a fairly large lumen and the thickening of the walls takes the form of numerous bars tapering from the base towards the apex of the cell; these cells appear as beaded polygons in surface view. In sesame seeds the palisade cells have thin walls and in the apex of each cell there is a spherical mass of small crystals of calcium oxalate measuring 12 to 40μ in diameter. (*b*) A layer of *sclereids* as in stramonium, capsicum, henbane, nux vomica. In the solanaceous seeds the thickening is usually on the radial walls and the base giving beaker-shaped cells and they are usually lignified. In lobelia the elongated polygonal cells are lignified and thickened strongly on the anticlinal walls and in strophanthus the cells are similar, but the

is appressed to

its side adjacen

sclereid-like epidermal cells which are extended as appressed trichomes with about ten rods of thickening, the cells being lignified in nux vomica and cellulosic in ignatius bean. (*c*) A layer containing *scattered sclereids* either singly or in groups as in almond, peach kernel, etc., the size and grouping of the cells enal

in the form of powder.

psyllium, ispaghula, cres

contains the pigment usually deposited in the substance of the cell walls as in the seeds of stramonium, henbane, belladonna, soy and colocynth. In other seeds the pigment is found in one of the inner layers of the testa, as in linseed and mustard where the cell-contents of a layer of the inner seed-coat are deeply coloured, and in cardamom where the cell-walls of the outer epidermis of the inner seed-coat contain the pigment. In ispaghula

and other plantain seeds the inner epidermis of the testa contains the colouring matter. The **sclerenchymatous** layer. In most seeds the cells of one or more layers have strongly thickened walls. In the solanaceous seeds, in nux vomica and in strophanthus the thickened layer is the outer epidermis and this has been referred to above. In the mustards, the inner epidermis of the outer seed-coat is developed as a sclerenchymatous layer. In cardamom and in linseed the inner epidermis of the inner seed-coat is sclerenchymatous, being composed of narrow elongated sclereids in linseed and of small cup-shaped cells in cardamom. In the seed of colocynth almost the entire testa, consisting of many layers of cells, is completely sclerotic. In kaladana, seeds of *Ipomœa hederacea*, it is the third layer of the testa which is developed as a strongly thickened palisade. In the seeds of *Ricinus communis* also, one of the inner layers of the testa consists of very strongly thickened elongated palisade cells. The **nutrient** layer of the testa is present in many seeds and consists usually of several layers of thin-walled parenchyma, the cells of which are filled with starch in the early stages of development of the seed from the fertilised ovule. As the thickenings of the various parts of the testa are laid down, the starch is gradually used and the thin-walled cells eventually collapse, forming a band of flattened cells. Such a band of collapsed tissue is found in linseed, in stramonium and other solanaceous seeds, in leguminous seeds, ispaghula and many other seeds.

When **perisperm** is present as a well-developed tissue, it is usually composed of a thin-walled parenchyma containing abundant starch, as in cardamom, pepper and grains of paradise (*Amomum Melegueta*). In other instances it is present in small amount, as in the nutmeg (*Myristica fragrans*), where the narrow perisperm proliferates on the inner side forming a secondary perisperm which develops infoldings which penetrate into the endosperm, forming the ruminations. In the castor seed (*Ricinus communis*) the perisperm appears as a very narrow film surrounding the endosperm and is often described as a tegmen.

Endosperm which is present in many seeds is composed of a cellulose-walled parenchyma containing food reserves. The walls are usually thin, but in some seeds such as nux vomica and ignatius bean, the walls become very thick, being largely composed of hemi-celluloses; in other seeds, such as the date (*Phœnix dactylifera*) they are so heavily thickened that they resemble stone-cells. The cells contain protoplasm and various reserve foods (see above). The **cotyledons** frequently show an approach to a typical leaf structure with a palisade layer beneath the upper epidermis; this is specially evident when cotyledons are not greatly enlarged to form a storage tissue for reserves. The radicle and, in the case of seeds with a small embryo, the entire embryo including the cotyledons is formed of small thin-walled cells.

Of the reserve foods found in seeds, the most characteristic are the protein reserves, which may be present as an amorphous mass completely filling the cells as in the endosperm of cardamoms, or may take the form of definite grains named **aleurone grains**. Seeds are the only plant members in which aleurone grains occur and hence a powder containing these grains may be known to have been derived from a seed. The aleurone may be segregated in a particular tissue or part of a tissue or it may be distributed throughout the tissues in association with other reserves. In cardamom it is present in the endosperm and starch is stored separately in the much larger perisperm. In many cereals, such as wheat and maize, the aleurone is confined to the outermost layer of the endosperm; in *Ricinus communis*, linseed and strophanthus it is stored in both embryo and endosperm in association with fixed oil and in peas and beans it is stored in the cotyledons in association with starch; in nutmeg, *Myristica*

fragrans, fat, aleurone and starch all occur together in the cells of the endosperm. Aleurone grains vary much in size, shape and complexity. They are frequently characteristic of particular seeds or of the seeds of particular families of plants. Consequently they are of service, something in the same way as starch grains, to enable one to obtain information about the systematic position of the plant in which they occur. Many aleurone grains are small in size and very simple in structure. Such grains consist of an amorphous mass of protein enveloped by a rather more dense protein membrane. This is the type of grain found in many Leguminous seeds (peas, beans, etc.), and in cereals. Other aleurone grains have

combination with an organo phosphoric acid. The particular organic acid radicle present is not definitely known; (3) calcium oxalate, usually in rosette form, but occasionally in prisms or needles. A grain may enclose one or two or more rarely several crystalloids and these may be accompanied by one or more globoids, as in *Ricinus communis*, in the soy bean *Glycine hispida*, and in linseed, *Linum usitatissimum*. In other seeds globoids occur as the only inclusions as in quince, *Pyrus Cydonia*, and ispaghula, *Plantago ovata*. Aleurone grains consisting of a ground substance enclosing one or two rosettes of calcium oxalate are the most common grains of umbelliferous seeds. In *Myristica surinamensis*, globoid, crystalloid and calcium oxalate rosette are all present together in the same grain. The size of aleurone grains is on the whole smaller than that of many starch grains; those of *Linum usitatissimum* are about 15μ, of *Ricinus communis*, about 10μ, of *Brassica alba* about 7 5μ and of *Foeniculum vulgare* about 5μ.

Protein and aleurone grains are insoluble in ether, alcohol and glycerin; they are stained yellow by solution of iodine. Water dissolves part of the

ammonium phosphate, from which characteristic crystals of magnesium ammonium phosphate ultimately separate, indicating the presence of magnesium in the globoids. Eosin in aqueous solution stains aleurone red, especially the ground substance and alcoholic picric acid stains it yellow, especially the crystalloids. Millon's reagent gives a white precipitate with proteins and the colour gradually changes to brick-red on standing or changes rapidly on warming gently.

Classification of Seeds

1. *Exalbuminous.*
    (a) Oily cotyledons and a straight embryo: Almond, Melon Pumpkin, Butea, Tonco, Peanut, Soy Bean.
    (b) Oily cotyledons and a folded embryo: Black Mustard, White Mustard.
    (c) Starchy cotyledons, straight with a small radicle: Calabar Bean, Guarana, Kola.

2. *Albuminous.*
  (*d*) Endosperm only present:
    (i) Embryo straight: Carbohydrate reserve is cellulosic. Nux Vomica, Ignatius Bean, Ispaghula, Psyllium.
    (ii) Embryo straight: C, H and O stored as oil. Chaulmoogra, Castor, Croton, Strophanthus, Linseed, Quince, Sesamo, Cacao.
    (iii) Embryo strongly curved: C, H and O stored as oil. Stramonium, Datura.
    (iv) Embryo folded: Endosperm mucilaginous. Fenugreek.
    (v) Embryo minute; embedded in abundant endosperm: Stavesacre, Sabadilla, Colchicum, Areca Nut.
  (*e*) Endosperm and perisperm present: Grains of Paradise, Nutmeg

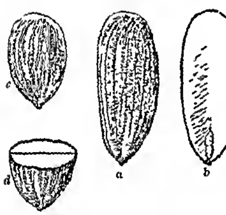


FIG. 50. Almond: *a*, Sweet Almond; *b*, same, cut longitudinally; *c*, Bitter Almond; *d*, same, cut transversely Natural size. (Holmes)

SWEET ALMONDS. Amygdala Dulcis

Sources. The sweet almond is the seed of *Prunus communis* Arcang, var. *dulcis* Schneider, family Rosaceæ. The tree is a native probably of Persia and Asia Minor, but is cultivated in all the countries that border on the Mediterranean.

Sicily and southern Italy are the chief almond-producing countries. Spain, Portugal, the south of France, the Balearic Islands, and Morocco also export considerable quantities.

Description. The variety used medicinally is the Jordan (French jardin) almond, exported chiefly from Malaga. This is about 20 to 30 mm. long, 10 to 16 mm. wide, and 8 mm. thick, and is flattened oblong-ovoid in shape. The testa is thin, brown and scurfy. One edge of the seed is more acute and the other is rounded. At the apex of the rounded edge is the linear hilum and the raphe runs from the hilum along the edge to the blunt end of the seed where the chalaza is situated. From the chalaza numerous vascular strands branch and extend towards the pointed end of the seed. The kernel consists of two large plano-convex oily cotyledons enclosing a stem apex and a small radicle. The thin inner membrane which is removed with the brown testa is in reality a very thin layer of endosperm. Odour none, taste bland and nutty. When triturated with water they yield a white emulsion, destitute of any marked odour.

Histology. The outer *epidermis* of the testa consists of polygonal cells with scattered, large, pitted, not very thick-walled sclerenchymatous cells occurring singly or in groups; individual stone cells vary from about 60 to 200μ in diameter, a large proportion being over 100μ, and up to 400μ high. In other related seeds such as kernels of prunes and apricots there is a similar epidermis, but the stone cells are smaller, being about 60 to 100μ in diameter in the apricot. Beneath the epidermis is a small amount of parenchyma; next a band of collapsed tissue and within that

some more parenchyma and an inner epidermis consisting of quadrangular or polygonal tabular cells about 10μ high and containing brown contents. The *aleurone* grains are mostly 3 to 7μ wide with a smaller proportion measuring 10 to 15μ; they contain globoids and the larger ones also a rosette or sometimes a prism of calcium oxalate.

Constituents. Sweet almonds contain from 45 to 50 per cent. of a bland fixed oil, which can be obtained by pressing the seeds, and about 20 per cent. of proteins, amongst which is included a mixture of enzymes known as emulsin. They contain also a little sucrose, gum, and asparagin.

Almond oil is pressed both from the sweet and the bitter almond. The oil is pale yellow, nearly inodorous and has a bland and nutty taste. It consists chiefly of olein accompanied by a small proportion of linolein, etc. It contains no stearin and it does not congeal above $-18°$.

Varieties. *Valencia*: these are broadly ovoid, shorter, and have a thicker, dusty brown, scurfy coat.

Sicilian and *Barbary*: both of these closely resemble the Valencia, but are rather smaller; they occasionally contain admixtures of bitter almonds.

Note. East Indian almonds are the seeds of the cashew nut, *Anacardium occidentale*, Linn., family Anacardiaceæ; the pericarp of the fruit contains an oily, vesicating liquid, cardol, but the seeds are edible.

Uses. Sweet almonds are demulcent and nutritive. They are used as a non-starchy food for diabetic patients.

BITTER ALMONDS. Amygdala Amara

Sources. The bitter almond tree (*Prunus communis* Arcang. var. *amara* Schneider) is indistinguishable from the sweet by any permanent botanical character and enjoys the same geographical distribution, although it is not cultivated to so large an extent.

Bitter almonds are imported chiefly from northern Africa, from Sicily, and from the south of France.

Description. In form and appearance bitter almonds closely resemble Valencia almonds, but they are usually smaller and less regular. They are usually about 20 mm. long, 12·5 mm. wide and 8 mm. thick; the markings on the testa resemble those on the sweet almond. They have, however, a bitter taste, and yield with water an emulsion easily distinguished from that of the sweet almond by its characteristic odour.

Histology. The microscopical structure resembles that of the sweet almond (see above).

Constituents. Bitter almonds resemble the sweet in containing both a bland fixed oil (40 to 45 per cent.) and proteins, the former of which is obtained by crushing the almonds between horizontal grooved rollers and pressing in powerful hydraulic presses. They contain also a colourless, crystalline glucoside, amygdalin (2·5 to 4 per cent.). This substance is left in the cake obtained after the oil has been expressed, and can be extracted from it by digestion with alcohol. It has a bitter taste and is odourless, but when an aqueous solution is mixed with an emulsion of sweet almonds the amygdalin is decomposed with production of benzaldehyde, hydrocyanic acid and dextrose.

This change is effected by the emulsin contained in the sweet almond. Emulsin is also contained in all the tissues of the bitter almond. When, therefore, bitter almonds (or cake) are crushed and mixed with water, the characteristic odours of benzaldehyde and hydrocyanic acid are developed. If, after standing a few hours, the mixture is subjected to distillation, an oily liquid of strong, bitter almond odour is obtained, together with a quantity of watery distillate; the oil is volatile (or essential) oil of bitter almonds, and consists of benzaldehyde and hydrocyanic acid, partly in the free state and partly combined as benzaldehyde cyanhydrin.

It can be freed from ... all t ... The ... ferro ... be obtained free from hydrocyanic acid by redistilling in a current of steam. No ... is developed by the sweet almond, becau ...

Bitter almonds yield from 0·5 to 0·8 ... 0·25 per cent. of hydrocyanic acid.

Many other Rosaceous plants contain amygdalin, such as the peach, apricot, plum, etc., not only in the seed, but also in the young shoots and flower-buds.

... als ... Prunus serotina El ... the hydrolysis is said to occur in three stages, each effected by a particular enzyme contained in the emulsin.

Uses. Bitter almonds are sedative, but as the poisonous hydrocyanic acid yielded by them varies in quantity they are unreliable. They are also employed for flavouring, but they should, for a similar reason, be used with caution.

Substitutes. *Apricot kernels* contain constituents similar to those of the bitter almond. They are imported in large quantities from Syria and California and are often used in the place of bitter almonds. The fixed oil expressed from them is commonly sold as "Oleum Amygdalæ Persicum" or "peach kernel oil." From the cake an essential oil (0·6 to 1·0 per cent.) is distilled as from bitter almond cake.

MELON PUMPKIN SEEDS. Cucurbitæ Semina Præparata

Sources. Melon pumpkin seeds are obtained ... Du ... sho ... that ...

D ... brittle; about ... have a ... of two ... they have a faint odour and ... taste.

Constituents. Melon pumpkin seeds contain an acrid resin to which their activity has been ascribed and about 30 per cent. of a reddish fixed oil together with proteins, sugar and starch. Recent experiments have failed to show that either the resin or the oil possesses therapeutic activity (Power and Salway, 1910).

Uses. As a tænicide.

BUTEA SEEDS. Buteæ Semina

Sources. Butea seeds are the seeds of *Butea frondosa* Roxburgh family Leguminosæ, a tree indigenous to India.

Description. The seeds are reniform in shape and very flat, from 25 to 38 mm. long, 16 to 25 mm. broad, and ... Seedcoat dark reddish ... near the middle ... and yellowish.

(about 19 per ce ... activity has been ... produce toxic symptoms, but neither the powder nor the fixed oil acts as an efficient anthelmintic (Mhaskar, 1923)

Uses. They are used as an aperient and anthelmintic, and are said to act as a rubefacient when pounded with lemon juice and applied to the skin.

TONCO BEANS. Semina Tonco

Sources. Tonco (tonka or tonquin) beans are the seeds of two species of *Dipteryx*, family Leguminosæ, viz., *D. odorata* Willdenow, and *D. oppositifolia* Willdenow, both trees of considerable size, the former a native of Guiana, the latter of Brazil.

Collection and Preparation. The tree bears an indehiscent, drupaceous fruit about the size of an egg, with a fibrous pericarp containing a single brownish-violet seed, about the size and shape of an almond. The fallen fruits are collected and split open, the seeds removed and dried on flat rocks. Sometimes they are placed upon the market without further treatment, but large quantities are brought from South America to Trinidad, where they are prepared for the European and American markets. This preparation consists in steeping them in rum, removing the excess and drying the seeds. By this treatment a white crystalline crust (of coumarin) is produced on the surface of the seeds; the latter may therefore occur "black" or "frosted"; when dry they are packed in cases or casks for shipment.

Description. Tonco beans closely resemble a Jordan almond in size and shape; they are 3 to 4 cm. long, 10 mm. wide and 8 mm. thick, and have a *nearly black, coarsely wrinkled surface* which, in the frosted seeds, is covered with minute, whitish crystals. The beans are rounded at one end but *terminate at the other in a broad, flat point*, just below which on the obtuse margin of the seed the micropyle appears as a brownish scar. Internally they are dark yellow, yellowish-brown, or nearly black, and consist of two large oily cotyledons, without endosperm, enclosing a plumule with two folded leaves and a short thick radicle.

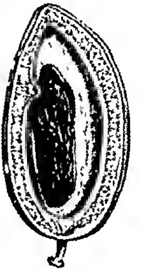


FIG. 60. Tonco bean. Fruit cut vertically, showing the seed. (Planchon and Collin.)

Tonco beans have a powerful and agreeably fragrant odour and an aromatic pungent taste.

Constituents. The seeds owe their fragrance to coumarin, of which they may contain as much as 3 per cent.

Varieties. The chief varieties of tonco beans are the Angostura and the Pará, each of which may occur frosted or black; the Angostura beans are the larger and more valuable.

Uses. Tonco beans find their principal use in perfumery; they are frequently mixed with vanilla beans in the preparation of extract of vanilla.

PEA NUT. Earth Nut, Ground Nut, Arachis seed

Sources. The Peanut is the seed of *Arachis hypogæa* Linn., family Leguminosæ, an annual plant which is a native of tropical South America and is cultivated in many tropical and sub-tropical countries including Nigeria, Kenya, China, Java and India. The plant grows to a height of 30 to 60 cm. and is remarkable because it exhibits the phenomenon of geocarpy, *i.e.*, the flower stalks grow downwards and bury the young fruits under the ground, where they ripen.

Description. Each pod contains one to three, usually two, seeds, which fill the pod so closely that they press upon one another and one becomes flattened at the hilar end and the other at the chalazal end; they are ovoid to ovoid cylindrical, 10 to 15 mm. long; the testa is brownish-red, brittle and papery; the kernel is yellowish-white and consists of two large fleshy plano-convex cotyledons, which are grooved on the flat surface, and a small radicle and plumule.

Constituents. The seeds contain fixed oil 40 to 50 per cent.; proteins 25 to 30 per cent.; starch 15 to 20 per cent., the starch grains are rounded and 5 to 15μ in diameter.

Arachis oil is pale yellow or greenish-yellow with a nutty odour and taste. Specific gravity 0·916 to 0·920; iodine value 85 to 99; saponification value 188 to 196; acid value not over 4; refractive index 1·4625 to 1·4645 at 40°; consists chiefly of the glycerides of arachic, stearic, lignoceric, oleic, hypogæic and linolic acids. It may be identified by saponifying a ml. with 15 ml. of N/1 alcoholic solution of potash, allowing the mixture to stand for twenty-four hours at 15·5°, heating on a water-bath for three minutes and again setting aside, when crystals of impure potassium arachate separate. Arachic or arachidic acid is remarkable for having a high melting point, viz., 77°.

SOY BEAN. Soja, Sojæ Semina

Soy beans are the seeds of *Glycine Soja* Sieb. eb Lucc. (= *G. hispida* Maxim.), family Leguminosæ, an annual herb cultivated in Manchuria, China, Japan, India and in parts of America and Europe.

Description. The seeds are rounded-ovoid and about 6 to 11 mm. long, 5 to 8 mm. wide, and 4 to 7 mm. thick; 100 seeds weigh from 14·5 to 33 gm.; they have a pale yellow or buff colour, though there are both brown and black varieties, a few seeds of which, usually less than 1 per cent, may be present in any given specimen. The testa is tough and somewhat translucent, and in the centre of one of the longer edges of the seed is the hilum, 3 to 4 mm. long, with the micropyle at one end and a small strophiole at the other end The embryo completely fills the seed and consists of two large plano-convex cotyledons with a small hypocotyl-radicle and plumule.

Histology. The palisade epidermis of the testa consists of polygonal prismatic cells 45 to 60μ high and 7 to 20μ wide, with pitted and thickened cellulosic anticlinal walls; the hypodermis consists of I-shaped "bearer-cells" 40 to 120μ high and 30 to 40μ wide at top and base and 18 to 30μ at the middle The remainder of the testa consists of somewhat flattened parenchyma; this is followed by a single layer of aleurone cells and some obliterated parenchyma, forming a hyaline layer in a transverse section. The cotyledons are composed of thin-walled parenchyma with a three-layered palisade on the flat side; the cells contain fixed oil and aleurone grains, about 3 to 11μ in diameter and showing a crystalloid and globoid. Scattered throughout the tissue of the cotyledons are cells, each containing a double prism of calcium oxalate, about 24·5μ long and 4 to 5μ wide. The hilum-furrow has a double epidermis and a group of tracheids abutting upon the end of the raphe, as is usual in leguminous seeds. Starch is absent from ripe seeds, but a few small grains may occasionally be found.

Constituents. Soy bean contains fixed oil, about 18 per cent., proteins, about 38 per cent., and the enzyme urease.

Soy bean oil is golden yellow, heated to 200° it becomes pale;

specific gravity 0·922 to 0·928, saponification value 190 to 195; iodine value 130 to 142; refractive index 1·4680 at 40°, contains about 12 per cent. of the glyceride of palmitic acid, and about 80 per cent. of the glycerides of oleic, linolic and linolenic acids.

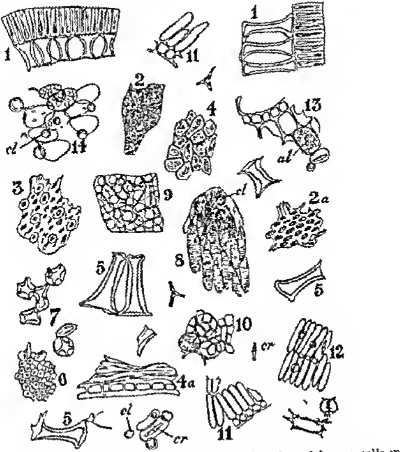


FIG 61. Powder of Soya bean 1. Palisade epidermis and bearer cells in transverse section. 2 Palisade epidermis in surface view from above 2a. The same from below 3. Palisade epidermis and bearer cells in surface view. 4. Aleurone layer within seed-coat in surface view. 4a. The same with compressed parenchyma in section. 5 Isolated bearer cells and portions of such cells 6. Upper layer of double epidermis from hilum, in surface view. 7 Modified parenchyma and sclerenchyma from region of hilum. 8 Tracheids from hilum furrow. 9. Epidermis and underlying cells from flat face of cotyledon. 10. Epidermis and underlying cells from rounded face of cotyledon. 11. Epidermis of flat face and palisade cells of cotyledon in transverse section. 12. Palisade cells from cotyledon 13. Epidermis and cells of mesophyll from rounded face of cotyledon. 14. Cells of mesophyll of cotyledon, al, aleurone grains; ol, oil globule; cr, calcium oxalate crystals. All × 150.

BLACK MUSTARD SEEDS. Semina Sinapis Nigræ

Sources. The black mustard plant, *Brassica sinapioides* Roth (*B nigra* Koch), family Cruciferæ, an erect annual plant attaining a height of 1 metre or more, is largely cultivated in Holland, England, Italy, Germany, and other countries. The fruits are smooth, erect, appressed siliquas, each

containing about ten or twelve minute dark seeds. These are separated when ripe, and dried.

Description. Black, or, as they are sometimes termed, brown or red, mustard seeds are of a dark reddish-brown or greyish-brown colour, sometimes nearly black, and are frequently partially covered with very thin whitish scales (dried mucilage from the epidermis, probably the result of damp). *They are nearly spherical and about 1 mm. in diameter.* One hundred seeds weigh from 0·14 to 0·17 gm. The surface of the thin and brittle testa is minutely reticulate, and the hilum is evident as a paler point Adherent to the inner surface of the testa is a thin membrane, which is the residue of the endosperm.

The kernel is greenish-yellow and oily ;
its two cotyledons placed face to face an
against the back of one of them, a positio
while the cotyledons are said to be incumbent upon the radicle. The cotyledons are themselves folded along their midribs so as to partially surround the dorsal hypocotyl-radicle. The seeds have no odour and a taste which is at first bitter and then strongly pungent. When the seeds are crushed and moistened with water they evolve a strongly pungent odour.

Histology. The testa consists of two coats, the outer being well developed while the inner one consists of a layer of collapsed cells. The *outer epidermis* is formed of polygonal tabular cells, about 40 to 55μ in tangential length and width, the lumina being almost completely filled with mucilage. The *hypodermis* consists of very large empty and flattened polygonal cells, tangentially about 70 to 85 to 105μ by 60 to 70 to 90μ, beneath which is the inner epidermis of the outer coat consisting of a *palisade* of small polygonal prismatic cells, about 7 to 15μ wide, which have a greater height, about 55μ, beneath the walls of the hypodermis, the intervening cells diminishing in height to about 25μ towards the centre of each hypodermal cell. The basal and anticlinal walls of this layer are thickened and lignified, giving them the form of beaker-cells and having the appearance of horse-shoe thickening in sections of the testa. The cells of the inner coat contain a dark-coloured *pigment* consisting of tannin and giving a blue colour with salts of iron. The thin membrane within the testa consists of a layer of moderately thick cellulosic-walled cells forming the *aleurone layer* and an underlying layer of collapsed cells. The cells of the aleurone layer contain fixed oil and aleurone grains. The tissues of the *embryo* consist of thin-walled polyhedral cells containing fixed oil and aleurone grains.

Constituents. Black mustard contains mucilage in the epidermis of the testa ; in the embryo there are about 27 per cent. of fixed oil, about 29 per cent. of proteins, about 4 per cent. of a glycoside, sinigrin, an enzyme, myrosin, and a small amount of acid sinapine sulphate. Sinigrin is also known as potassium myronate. In the presence of water, the myrosin acts upon sinigrin to yield glucose, potassium acid sulphate and allyl iso-thiocyanate. This latter substance is a volatile oily material and responsible for the powerful pungent taste and odour obtained by moistening the powdered seeds. From 0·7 to 1·3 per cent. of volatile oil can be obtained from the seeds and the oil contains at least 92 per cent. of allyl iso-thiocyanate.

Uses. Applied externally, black mustard acts as a rubefacient and counter-irritant ; this effect is followed by loss of sensibility in the part, and consequently relief from previous pain. Prolonged action may result in vesication. Internally, mustard is used as a condiment and in full doses as an emetic.

Note. *Indian mustard* (*B. juncea* Hooker and Thoms) is widely cultivated in southern Russia and India ; the seeds resemble black mustard

but are rather larger and browner in colour; the volatile oil is believed to contain about 40 per cent. of allyl isothiocyanate and 50 per cent. of crotonyl isothiocyanate, C_4H_7NCS; they are sometimes sold as black mustard seeds.

WHITE MUSTARD SEEDS. Semina Sinapis Albæ

Source, etc. *Brassica alba* Boissier, family Cruciferæ, the white mustard, is cultivated like the black mustard, which it closely resembles, but not to so large an extent. It differs from the black mustard in producing more or less horizontal, hairy fruits, those of the black mustard being erect, appressed and smooth. Each fruit contains from four to six seeds.

Description. White mustard seeds are yellow in colour, nearly spherical in shape, and about 2 mm. in diameter. The seed-coat is very minutely pitted, the pits being so small that the seed appears smooth until examined with a lens. Internally the seed resembles in structure that of black mustard. It becomes coated with mucilage when soaked in water.

White mustard seeds, either whole or powdered, are free from pungent odour, even when triturated with water. They have a pungent taste.

Histology. White mustard closely resembles black mustard in structure

absence of a distinct polygonal network in surface view of the testa as seen in black mustard. The inner seed coat is also devoid of colouring matter.

Constituents. White mustard seeds contain a fixed oil (about 30 per cent.), mucilage (in the epidermis of the seed-coat), and proteins (about 25 per cent.). Starch is not present in the ripe seeds, which yield about 4 per cent. of ash. They contain, in addition, a crystalline glucoside, sinalbin, and the same enzyme as is found in the black mustard seed—viz., myrosin. Sinalbin is readily soluble in water and in boiling alcohol, but only very sparingly in cold alcohol; it assumes an intense yellow colour when acted upon by alkalies. Under the influence of myrosin in the presence of water, it yields acid sinapine sulphate, dextrose, and acrinyl (parahydroxybenzyl) isothiocyanate. The decomposition may be represented by the following equation:

$$\underset{\text{Sinalbin}}{C_{30}H_{44}N_2S_2O_{16}} = \underset{\text{Acrinyl isothiocyanate}}{C_7H_7O.N{:}C{:}S} + \underset{\text{Dextrose}}{C_6H_{12}O_6} + \underset{\text{Acid sinapine sulphate}}{C_{16}H_{24}NO_5HSO_4}.$$

Of these three substances, acrinyl isothiocyanate is a yellow oily liquid with a pungent taste and powerful rubefacient action, but as it is not volatile it is destitute of pungent odour or pungent effect on the eyes. Sinapine is an unstable alkaloid that has not yet been isolated; the acid sulphate and other salts ... yellow colour

... ant properties

CALABAR BEAN. Semina Physostigmatis, Ordeal Bean, Eseré Nut

Sources. Calabar beans are the ripe seeds of *Physostigma venenosum* Balfour, family Leguminosæ, a woody climbing plant indigenous to the west coast of Africa, especially near the mouths of the Old Calabar and Niger rivers. It ascends trees and, drooping down, bears pendulous racemes of flowers. These are succeeded by legumes about 15 cm. in length, in each of which two or three large seeds are contained. Calabar beans have long been used on the west coast of Africa as "ordeal" beans,

They became known in England in 1840; their power of contracting the pupil of the eye was discovered by Fraser in 1862.

Description. Calabar beans are about 25 to 30 mm. long, 15 to 18 mm. in maximum breadth and 10 to 15 mm. thick and are oblong-reniform in shape. The testa is dark reddish-brown, hard, thick, shiny and somewhat rough. The hilum forms a deep black groove about 2 mm. wide extending the entire length of the curved edge of the seed and passing completely round the more blunt end. The micropyle is at the more acute end of the seed adjacent to the end of the hilum. Within the testa are two concavo-convex starchy cotyledons. The hollow between the cotyledons, being filled with air, causes the seeds *to float on water.* The *seeds* have no odour and the taste is bean-like; they are very poisonous.

Constituents. Calabar beans contain about 0·04 to 0·3 per cent. of physostigmine (also named eserine), about 48 per cent. of starch and 23 per cent. of proteins. There are also traces of several other alkaloids and a small amount of fixed oil.

Physostigmine, $C_{15}H_{21}O_2N_3$, forms colourless rhombic crystals melting at 105°, or 86° to 87°, the alkaloid being dimorphous; aqueous solutions of

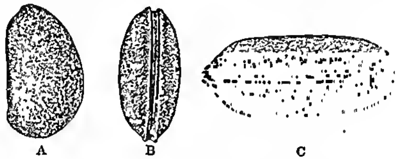


FIG 62. *A* and *B*, Calabar bean, *Physostigma venenosum*. *A*, side view showing sub-reniform shape. *B*, edge, showing the long hilum. *C*, seed of *P. cylindrospermum* showing the shorter hilum. (After Maisch.)

its salts rapidly become pink, due to conversion of the physostigmine into rubresorine; it powerfully contracts the pupil of the eye.

Substitutes. *P. cylindrospermum* Holmes; seed nearly cylindrical, hilum shorter; were imported in 1879 and are said to contain physostigmine.

Mucuna urens de Candolle, family Leguminosæ (horse-eye beans); brownish and rounded.

Entada scandens Bentham, family Leguminosæ (garbee beans); flattened discoid, 5 cm. in diameter.

Pentaclethra macrophylla Bentham, family Leguminosæ, mussel-shaped; 7 cm. long, 5 cm. wide.

Uses. Calabar beans are chiefly used as a source of the alkaloid physostigmine, which is much employed to produce contraction of the pupil of the eye. Both the drug and the alkaloid have been employed in tetanus, locomotor ataxy, and as an antidote in cases of strychnine poisoning; large doses produce an increase of blood-pressure, retardation of respiration, and finally death by asphyxia.

GUARANA. Pasta Guaranæ

Source, etc. Guarana is prepared from the seeds of *Paullinia Cupāna* Humboldt, Bonpland, and Kunth, family Sapindaceæ, an elegant climbing shrub indigenous to and common in Brazil, especially in the basins of the

Amazon and its tributaries. It derives its name from the Guarinis, an aboriginal tribe of Indians.

Collection and Preparation. The difficulty of collecting the seeds from the wild plants, which, though common, are not easily accessible, has apparently led to their cultivation, the plants being trained to poles like hops. When the pods open to discharge the ripe seeds they are collected. The seeds are sub-spherical with a deep red-brown, shining testa; they are about 11 to 12 by 8 to 10 by 8 mm., somewhat flattened at the base where there is a small cupule-like aril. The seed is exalbuminous and has two sub-hemispherical starchy cotyledons. They are first washed and then roasted to loosen them from a papery testa, from which they are partially freed by beating. The broken kernels are made into a dough with water; this is then divided and moulded into masses of varying size and shape, sometimes representing an animal (fish, turtle, lizard, dog, etc.), fruit or leaf, which are finally dried at a gentle heat by means of a slow fire From the hard mass thus obtained portions are grated off with a large file, made from the dried rough tongue of the fish, *Arapaima gigas*,[1] and served in glasses of water, forming a refreshing drink.

Description. Guarana commonly appears on the market in the form of extremely hard, heavy, sausage-shaped masses, varying from 10 to 30 cm. in length and from 2·5 to 4 cm. in thickness. The outer surface is dark chocolate-brown in colour, and would be smooth and uniform were it not that small angular fragments, often of lighter colour than the rest, project slightly; these fragments are evidently the larger pieces of the broken seed. The fractured surface, smoothed with a knife, is reddish in colour, and exhibits, like the outer surface, small, paler, irregular fragments embedded in a darker, reddish mass, but no definite structure is discernible. The powder, in which form the drug is administered, is of a pale, red colour; it has a scarcely perceptible odour and slightly astringent, bitter taste.

Constituents. Guarana contains from 2·5 to nearly 5 per cent. of caffeine, guaranatin, a little catechu-tannic acid, abundance of starch, and a little fat. The caffeine exists in the seeds in combination with the guaranatin, possibly as an unstable glycoside which splits up into caffeine, guaranatin and sugar, the guaranatin passing into guarana-red

Adulteration. The amount of caffeine should not be less than 2·5 per cent. Microscopical examination has shown the presence of the seed-coats, which may have been only imperfectly separated, and frequently of foreign starches. Thoms (1894) found in guarana 8·63 per cent. of moisture, 1·63 per cent. of ash, and 2·68 per cent of caffeine, the seeds themselves yielding closely concordant figures.

Uses. Guarana is employed as a nervine stimulant in the same way that tea and coffee are, and produces similar effects. It has been long in common use in Brazil.

COLA SEEDS. Semina Colæ

Source, etc. Cola seeds, sometimes called Cola or Kola nuts, Gooroo nuts, or Bissy nuts, are obtained from *Cola vera* Schumann, family Sterculiaceæ, a large and handsome tree resembling in habit the Spanish chestnut. It is a native of tropical Africa, growing wild in Sierra Leone, North Ashanti, near the sources of the Niger River, etc., but cultivated in other tropical countries, such as the West Indies, Brazil, Java, etc , our supplies being derived either from the west coast of Africa, or from the West Indies.

[1] *Arapaima gigas* lives in the river Amazon and is the largest known fresh water fish, attaining a length of 15 feet.

Collection and Preparation. The woody, capsular fruit of the tree contains from five to fifteen large white or crimson seeds which are removed and deprived of their seed-coats, the kernels only being used; these are chewed whilst still fresh, either before or after germination, and have been highly valued by the negroes for many centuries for their stimulating properties, in which they resemble tea, coffee, cocoa, etc.

Large quantities of the seeds are collected and consumed by the natives, who also carry on a considerable trade in them. Packed in baskets with the leaves of the cola tree they can be kept fresh, and in this state are brought chiefly from Lagos to Sokoto, Kano, and Timbuctoo, whence they are distributed to other parts of Africa. The fresh seeds are also occasionally exported, but more commonly the kernels are separated into the two large fleshy cotyledons and dried, during which the white or crimson colour changes to a dull reddish-brown.

Description. Dried cola seeds, as commonly seen in this country, consist of the kernels only of the seeds, sometimes entire, but more often separated into the two cotyledons. Externally, they have a dull dark brown or reddish-brown colour; internally they are usually somewhat paler. They are hard and solid, and exhibit, when cut, a perfectly uniform ... ey are about 2 to 5 cm. ... In shape they may be ... ge-shaped, or irregularly six-sided. A shallow furrow encircles the kernel, where the two cotyledons meet; transverse to this furrow at one end of the seed, a distinct cleft may be found, partially separating each cotyledon into two portions. Complete kernels may easily be separated into their constituent cotyledons, and the small radicle will be found towards the bottom of the transverse cleft. Fresh cola seeds have a bitterish astringent taste, which is scarcely perceptible in the dry seed; the latter are also destitute of any marked odour.

Constituents. Cola seeds contain caffeine (1 to 2·5 per cent.), kolatin (0·75 per cent.), and traces of theobromine. There are also present kolatein, an oxydase enzyme, fat, sugar, and abundance of starch.

Kolatin, $C_8H_{10}O_4$, is crystalline, slightly soluble in water, but readily in alcohol. In the fresh seeds the caffeine and kolatin are combined, in the form of an unstable kolatin-caffeine glucoside. During the drying of the seeds the kolatin is converted by the oxydase into kola-red, caffeine being simultaneously liberated. Kola-red is allied to the phlobaphenes, and is present in the dried drug to the exclusion of kolatin, imparting to it the characteristic colour. If, however, the fresh seeds are boiled and the oxydase thus destroyed, they retain, when dried, the colour of the fresh seeds and contain the kolatin. The fresh seeds may also be preserved by beating them into a pulp with an equal weight of loaf sugar.

Uses. Cola seeds have properties similar to those of tea, coffee, etc., and are used as a nerve stimulant. Kolatin was found to increase the energy of the cardiac contractions, and as this substance is not present in the commercial drug, it having been converted into kola-red, the therapeutical action of the dried seeds is somewhat different from that of the fresh; hence possibly the strong preference in Africa for the fresh seeds. The action of the dried *sterilised* seeds resembles that of the fresh.

Varieties. *C. acuminata* Schott and Endlicher; Cameroon and Congo States; the seeds have three to five cotyledons; they are eaten like the genuine, and are sometimes imported, but contain less caffeine and are less esteemed.

C. Ballayi Carnu; Gaboon; the seeds have six cotyledons and contain but little caffeine.

C. astrophora Warburg, the red cola of the Adhantis, always has red

seeds; *C. alba* the white cola of the Ngaus, always has whitish seeds. *C. vera* is said to be a hybrid of these two species; its seeds are sometimes red, sometimes white.

Other seeds have from time to time been substituted for cola seeds, but the genuine are easily distinguished by the characters given.

NUX VOMICA. Semina Strychni, Nux Vomica. Crow Fig

Sources. The nux vomica tree, *Strychnos Nux-vomica* Linn. Family

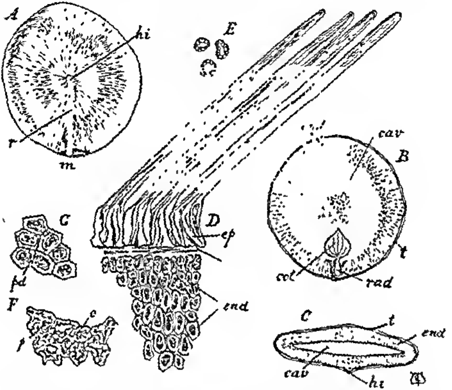


FIG. 63. *Seed of Strychnos Nux-vomica.* *A*, external surface of seed. *B*, section of seed parallel to the flat faces. *C*, section at right angles to the flat faces. *D*, transverse section of outer part of seed. *E*, transverse sections of limbs of trichomes. *F*, bases of trichomes in surface view. *G*, cells of endosperm show... projec-ti[illegible] ...es of tr[illegible] ; *ep*, e[illegible] *rad*, r[illegible]

Loganiaceæ, is a small tree [illegible] also in Ceylon, Siam, and [illegible] have been unaware of its [illegible] Europe in the sixteenth century, but was not much used in medicine, being chiefly employed to poison dogs, cats, crows, etc.

Collection and Preparation. The nux-vomica tree grows wild on the hills of the Malabar coast in Travancore and Cochin and also on the Coromandel coast in the districts of Ganjan, Godavery and Nellore, these hills are respectively the Western and Eastern Ghats of southern India

The fruits are sub-spherical and about 3 to 5 cm. in diameter with a leathery epicarp and a bitter whitish pulp in which from three to five seeds are embedded. The fruits are collected by members of the forest tribes in the districts named above, the seeds are removed and washed free of any adherent pulp; they are then dried in the sun on "mats." Seeds

, any pieces

the surface

are usually

marketed uncleaned and unsorted. The finest seeds come from Ceylon.

Description. The seeds are disc-shaped, being about 20 to 25 mm. in diameter and 4 mm. thick, of an ash-grey or greenish-grey colour. They are usually not quite flat, being a little depressed on one side and arched on the other, or sometimes irregularly bent. They are covered with numerous, closely appressed hairs, radiating from the centre to the circumference, to which the satiny sheen of the seeds is due. The edge of the seed is sometimes rounded, sometimes acute, according to the variety, at one point on the margin, where the micropyle is situated, there is a distinct prominence from which a raised line passes to the centre of the seed. This line does not exist in the fresh seed, but makes its appearance during the drying and disappears when the dry seed is soaked in water. The hilum is in the centre of either the raised or depressed surface. Beneath the single seed-coat there is a lining of horny endosperm about 2 mm. thick, leaving a central narrow disc-shaped cavity about 16 to 20 mm. in diameter and up to 1·5 mm. wide at the centre. The endosperm is perforated above the micropyle by a cylindrical channel leading into the disc-shaped hollow and enclosing the terete radicle of the embryo. Attached to the radicle and lying within the hollow are two cordate leafy cotyledons having a distinct palmate venation with five to seven veins. The cotyledons are about 5 to 6 mm. long and the radicle about 4 mm. The endosperm is translucent grey in colour and the embryo is whitish. The seeds are almost odourless and have a persistent and intensely bitter taste. Nux vomica seeds weigh from 1·4 to 2·4 gm. each; small inferior seeds may weigh as little as 0 5 gm each.

Histology. The testa is about 0·1 mm. thick, the greater part being formed by the epidermis. Each *epidermal* cell is extended to form an appressed trichome about 600 to 800 to 1,000μ long and 25μ in diameter. The basal portion is about 75μ high and broad and of about the same width; the walls are strongly thickened and lignified, the anticlinal walls being undulated and pierced by tubular pits which are sometimes more or less spirally twisted. The limb of the trichome has about ten longitudinal ribs of lignified thickening upon its wall. The inner region of the thin testa consists of collapsed cells forming a layer about 25μ in thickness.

protoplasts of the endosperm cells communicate through the cell-walls by means of very fine protoplasmic threads—termed *plasmodesma*—appearing in sections as numerous very fine lines crossing the walls and rendered more evident by staining with iodine. Fixed oil is present in the meshes of the

protoplasm as also are *aleurone* grains. These grains are from 15 to 30μ wide or even up to 50μ and of various irregular shapes; they do not contain crystalloids, but several globoids are usually present in each grain.

The length of lignified rib per milligramme of air-dry nux vomica has been measured. Several varieties of seed were examined and gave the values 167 to 184 to 206 cm. of rib per milligramme of air-dry seed. This value can be used to determine the amount of powdered nux vomica present in mixtures containing it. (Wallis and Fairbairn, 1943.)

Constituents. Nux vomica seeds contain 1·54 to 2·8 to 5·3 per cent of total alkaloids consisting chiefly of strychnine and brucine, from 35 to 50 per cent. of the total amount being strychnine. The average amount of strychnine is 1·23 and of brucine 1·55 per cent. The seeds contain about 3 per cent of a viscous fixed oil and also chlorogenic acid, formerly named igasuric or caffeotannic acid, which occurs in maté, the leaves of *Ilex paraguensis* St Hil. and in coffee, seeds of *Coffea arabica*. Chlorogenic acid is changed to green viridic acid on exposure to air and ammonia.

Less important constituents are traces of an alkaloid strychnicine, found more abundantly in the leaves and also of the glycoside loganin, which occurs in the pulp of the fruit and is identical with meliatin, isolated by Bridel (1910) from *Menyanthes trifoliata*, family Gentianaceæ.

Action and Uses. Nux vomica is largely used as a bitter stomachic and tonic. It stimulates the muscular coat of the intestine, increasing peristalsis, and hence is given in constipation from an atonic condition of the intestine. It increases the blood pressure, and is therefore valuable in certain cases of cardiac failure. In large doses the excitability of the motor nerve cells is so much increased that violent convulsions may occur; these involve the respiratory muscles, and death ensues from asphyxiation

Substitutes and Adulterants. The seeds of *Strychnos potatorum* Linn., and of *S. Nux-blanda* Hill, have been offered as nux vomica The former are smaller, thicker and free from bitterness; they are used in India for clearing turbid water, being usually known as "clearing nuts." The latter closely resemble nux vomica, but may be distinguished by the small ridge on the edge and by their brighter, yellowish-buff colour; they are also free from bitterness (and consequently from strychnine and brucine)

IGNATIUS BEANS. *Semina Ignatii*

Sources, etc. Ignatius beans are the seeds of *Strychnos Ignatii* Bergius family Loganiaceæ, a stout climbing plant with woody stem, indigenous to the southern Philippine Islands. It became known to Europeans through a Jesuit, Father Camellus, towards the end of the seventeenth century, and the seeds were called Fabæ Sancti Ignatii, in honour of Ignatius Loyola, the founder of the order. The large ovoid or nearly globose fruit contains about twelve seeds embedded in a pulp, from which they are separated and dried.

Description. Ignatius beans are dull, dark grey, irregularly ovoid and about 25 mm. long, usually having one large curved side and three or four smaller, flattish surfaces with rounded angles. Here and there are patches of the dull, ash-grey seed-coat, covered with appressed hairs, which differ from those of nux vomica, in being less regularly arranged, unlignified and devoid of any satiny sheen. Usually the seed coat, which is

very thin, has been removed by the friction of the seeds against one another, exposing the surface of the dark, translucent, horny endosperm. The hilum appears as a circular area at one extremity of the seed.

The embryo with its small radicle and leafy cotyledons lies in a shallow

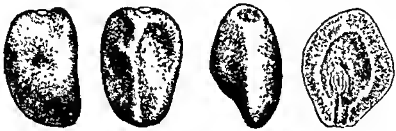


FIG 64. Ignatius Beans. Natural size. (Bentley and Trimen.)

disc-shaped cavity in the endosperm similar to that of nux vomica The seeds are inodorous, but have an extremely bitter taste.

Constituents. Ignatius beans contain strychnine and brucine to about the same extent as nux vomica, viz., 2·5 to 3 per cent. of total alkaloid, of which from 46 to 62 per cent. is strychnine.

Uses. The drug possesses a medicinal action similar to that of nux vomica, over which it has no evident superiority.

ISPAGHULA. Ispaghul, Spogel Seeds

Sources. Ispaghul consists of the dried seeds of *Plantago ovata* Forskal family Plantaginaceæ, a herb widely distributed in the Punjab, Sind and Persia.

Description. The seeds are about 1·8 to 3·3 mm. long and 1 to 1·7 mm. wide, boat-shaped, pale greyish-brown in colour, usually with a pinkish tinge; on the convex surface there is a central, brown oval spot; on the concave surface is the hilum covered with a thin, whitish membrane; 100 seeds weigh 0·15 to 0·19 gm. When soaked in water the seed coat swells and the seeds become surrounded with a transparent, colourless mucilage free from taste and odour; 1 part of the seeds forms a thick, tasteless jelly with 20 of water. The swelling factor is 10 25 to 13·5.[1]

Constituents. The chief constituent is the mucilage which is contained in the cells of the epidermis; it swells and dissolves when the seeds are immersed in water.

Uses. In dysentery and chronic diarrhœa; largely used in Northern India as a specific for all kinds of intestinal irritation; they may be taken dry or after soaking in water; they are also used as a poultice and as a mechanical laxative.

Ispaghula Husk consists of the epidermis separated from the seed. The drug has the appearance of tiny transparent flakes each having a brown oval spot upon it. The swelling factor is 90. This preparation forms a component of various laxative mixtures.

PSYLLIUM. Flea Seed

Sources. Psyllium consists of the seeds of *Plantago Psyllium* Linn. and of *P. arenaria* Wald. et Kit., family Plantaginaceæ. The drug is imported chiefly from the south of France.

[1] The swelling factor is obtained thus:—1·0 gram is agitated gently and occasionally during 24 hours in a 25 millilitre cylinder filled to the 20 mil. mark with distilled water and then allowed to stand for one hour; the volume now occupied by the swollen seeds is the *swelling factor*.

Description. These seeds resemble ispaghula in general characters. Seeds of *P. Psyllium* are 2 to 3 mm. long and 0·75 to 1·0 mm. wide, and 100 seeds weigh from 0 09 to 0·10 gm. Their swelling factor is 12·75. They are dark brown, shining and glossy, rounded oblong and very transparent, showing the embryo ; there is a slight constriction across the centre of the dorsal surface and a white membranous patch is present in the centre of the brown furrow. The seeds of *P. arenaria* are 2 0 to 2 5 mm. long and 1·0 to 1·5 mm. wide, and 100 seeds weigh from 0 12 to 0·14 gm. The swelling factor is 14·5. They are blackish-brown with a rather dull surface, elliptical in outline with a constriction across the centre of the dorsal surface ; the furrow is deep brown with a central white membranous patch in the form of a figure 8.

Constituents. The chief constituent is mucilage contained in the cells of the epidermis.

Uses. Psyllium is a valuable mechanical laxative and is used both alone and also associated with senna, cascara and other purgatives.

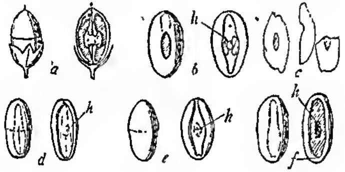


FIG. 65 ...

of the furrow. All seeds × 5

Adulterant. Seeds of *Plantago lanceolata* Linn may be mixed with psyllium ...
long and ...
they are ...
on the c...
They contain very little mucilage, having a swelling factor of 4·75.

CHAULMOOGRA SEEDS and Hydnocarpus Seeds

Sources. Chaulmoogra seeds are the seeds of *Taraktogenos Kurzii* King, a tree growing in Burma ; Hydnocarpus seeds are derived from *Hydnocarpus Wightiana* Blume, a tree growing in the Deccan and south-west India, family Flacourtiaceæ.

Description. The seeds of *Taraktogenos Kurzii* are irregularly ovoid, 2 to 3 cm. long and 1 to 1·5 cm. wide, with a smooth and brittle testa ; they contain an abundant oily dark brownish endosperm, in which is embedded an embryo with two large foliaceous, three-nerved cotyledons and a ... s are similar to ...

... ied in the sun ; ... testa is cracked and removed ; the kernels are beaten to a paste and put into square jute bags about 30 cm. square and 5 cm. thick ; these are

piled up and the oil is expressed by a hydraulic press. This pro
carried on at Chittagong.

Hydnocarpus oil is prepared from seeds of *Hydnocarpus Wightian*
similar process.

The two oils are very similar in physical characters and ch
constants, that of *H. Wightiana* is a yellow
characteristic odour and somewhat acrid t
0·950 to 0·960; melting point 20° to 25°;
1·476; acid value not more than 25; saponification value 198 t
iodine value 97 to 103. Contains palmitic acid, chaulmoogri
hydnocarpic and other acids.

Uses. Used for leprosy, psoriasis and rheumatism both interna
externally, usually in the form of the ethyl esters of the mixed acid
oils from the seeds of *Hydnocarpus anthelmintica* Pierre and other
are used for the same purpose.

CASTOR SEEDS. Castor-oil Seeds, Semina Ricini

Sources, etc. The castor-oil plant, *Ricinus communis* Linn.,
Euphorbiaceæ, is indigenous to India, but is diffused now o
tropical and subt
countries. In India i
attain a height of 40
and be a perennial tr
in cooler climates it is
a shrub or an annual
The plant, and with
seed, is subject to
variation, the large,
rescent forms yielding
seeds, the small,
varieties small seeds
market is chiefly su
from India and
America, but consid
quantities of the seed are raised in other countries, as, for instan
Italy.

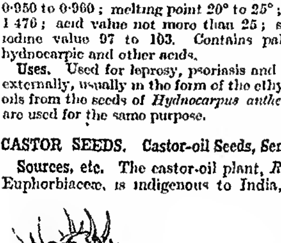


Fig 66. Fruit and seed of *Ricinus communis*. Natural size. (Bentley and Trimen.)

Cultivation and Collection. The smaller varieties of castor seed are
cultivated for the production of medicinal oil. The seeds are first s
in water and then sown in well and deeply tilled soil, in holes about
apart, three or four seeds being put in each hole. The plants are
thinned out so as to leave only the strongest, which are spaced
1·5 to 2 metres apart. The plants begin to bear when four to six m
old and the number of spikes of flowers on each plant is increas
nipping back the main stem. When the capsules begin to turn brow
spikes of fruits are collected and exposed to the sun on concrete floo
layer about 15 cm. deep. Once
rake, and after three or four
seeds are flung out violently.
to a height of 1 to 2 metres
are removed by winnowing.

Description. The fruit is a dry three-celled, three-seeded ovoi

and smooth, grey to red-brown and marbled with reddish brown or black spots and stripes. They are oval and slightly flattened, the flatter ventral surface being slightly ridged; along the rounded ridge the raphe extends from the caruncle at the hilar end of the seed to the chalaza at the other extremity. Within the testa is a delicate colourless membrane surrounding the kernel; this membrane is the remains of the nucellus. The kernel consists of an abundant oily endosperm, having a wide, but very narrow, central cavity in which lie the two colourless leafy cotyledons of the embryo, the radicle of which pierces the layer of endosperm and points towards the micropyle immediately beneath the caruncle. The seeds have a slight odour and a weakly acrid taste.

Constituents. Castor seeds contain about 50 per cent. of fixed oil and about 26 per cent. of proteins.

The cake left after the expression of the oil contains about 0·2 per cent. of ricinine (Tuson, 1864), a crystalline principle melting at 201·5°, ricin (Stillmark, 1889), a toxin similar in nature to the bacterial toxins, and also (ripe seeds) a very active lipase (fat-splitting enzyme) and other enzymes. Both castor seeds and the cake left after the expression of the oil act as violent purgatives, a property probably due to the ricin contained in them.

Ricin is very poisonous, about 7 mg. being fatal to an adult; it is left in the cake when the seeds are pressed and renders it unfit for cattle food.

Uses. On account of their violent action, the seeds themselves are never employed in this country, though in some countries they are said to be a favourite purgative. They are used as the source of castor oil.

Note. Semina Ricini Majores (Physic Nuts, Purging Nuts, Pignons d'Inde) are the seeds of *Jatropha Curcas* Linn.; they resemble castor seeds in shape, but are rather larger, dull black; surface minutely rugose with small white patches; they contain a fixed oil, much more purgative than castor oil, and curcin, a toxin belonging to the same group as ricin.

CROTON SEEDS. Semina Crotonis

Source, etc. Croton seeds are the seeds of *Croton Tiglium* Linn., family Euphorbiaceæ, a small tree indigenous to and cultivated in India. They were used medicinally in the seventeenth century, but fell into disuse owing probably to the violence and uncertainty of their action. The oil was introduced from India about 1810, and was found to be, in certain cases, a valuable cathartic.

The tree produces a three-celled, three-seeded capsular fruit resembling that of the castor plant, but devoid of spines. The seeds are exported, and the oil pressed from them in this country.

Description. Croton seeds are about 10 to 13 mm. long, 7 to 9 mm. wide and 6 to 8 mm. thick. The hard, brittle testa is dull cinnamon brown and the ventral surface has a distinct ridge, the dorsal surface also forms a low rounded ridge. Both externally and in its structure the seed closely resembles castor seed, but is more quadrangular in transverse section and the caruncle, which is easily detached, is rarely present in the drug.

The outer, brown layer is easily removed, disclosing a dark surface; in many commercial specimens the friction of the seeds against one another has been sufficient partially to effect this, giving the seeds a mottled appearance.

The taste of the kernel, in ascertaining which great caution is necessary, is at first oily, but this is succeeded by an unpleasant acridity; the seeds have no marked odour.

Constituents. Croton seeds contain about 50 per cent. of fixed oil the medicinal properties of which are due to croton-resin (Dunstan, 1895), which has been obtained as a nearly colourless, light powder soluble in all proportions in organic solvents with the exception of petroleum spirit (Boehm, 1920).

The seeds also contain about 18 per cent. of proteins amongst which are the toxic albumoses croton-globulin and croton-albumin, which together are also known as crotin and resemble ricin. Croton oil is brownish-yellow and slightly fluorescent; it is soluble in less than its own volume of absolute alcohol, but on further addition of alcohol two layers are formed, the active constituent of the oil being contained in the alcoholic layer. The solubility appears to depend on the proportion of free acid present and to increase with the age of the oil.

Uses. Croton oil is a powerful irritant, producing, when applied to the skin, a burning sensation and redness, followed by severe pustules; it is used, diluted, as a counter-irritant. Internally it is a very rapid, drastic cathartic, and is given in certain cases of apoplexy and of obstinate constipation.

STROPHANTHUS SEEDS. Semina Strophanthi

Sources and History. Strophanthus seeds are obtained from *Strophanthus kombe* Oliver, family Apocynaceæ, a climbing plant of considerable size, indigenous to eastern tropical Africa, near the Nyanza and Tanganyika lakes, the Shiré river, etc. An extract prepared from them (and possibly from the seeds of other species of *Strophanthus*) is used in Africa as an arrow poison. Specimens of this extract were sent to England in 1861–1864 and recognised by Sharpey (1862) as a cardiac poison. The seeds were examined by Fraser (1885), who isolated the active principle strophanthin, and recommended the seeds as a substitute for foxglove leaves.

[illegible]

number of seeds provided with long awns. The fruits are collected when ripe, and are sometimes exported after having been freed from their epicarp and fleshy mesocarp. More commonly the seeds, separated from the fruits and deprived of their awns, are sent into commerce, chiefly from Beira, Somba, Quilimane, Inhambane, Chindo and other East African ports.

Description. The seeds are lanceolate or linear lanceolate and the testa is prolonged at the apex into a slender thread-like awn which terminates in a plume of silk [illegible] awn and plume is from 10 to [illegible] long and about 3 cm. wide. [illegible] exportation, so that the commercial seed is about 12 to 20 mm. long, 3 to 5 mm. broad and 2 mm. thick; at the apex is a broken point left by the removal of the awn and at the base a slight inconspicuous winged extension. A ridge, which contains the raphe, runs from the apex along the central line of one of the broad faces of the seed for about two-thirds of its length; near the apical end of this ridge the

hilum appears as a whitish point. The testa bears appressed trichomes directed towards the apex and arranged in close longitudinal lines; these trichomes give a silky sheen to the seeds, which are greyish-green to fawn in colour. Within the testa the large straight embryo is enveloped by a layer of endosperm about 0·5 mm. thick. The radicle is directed towards the apex and the two lanceolate plano-convex

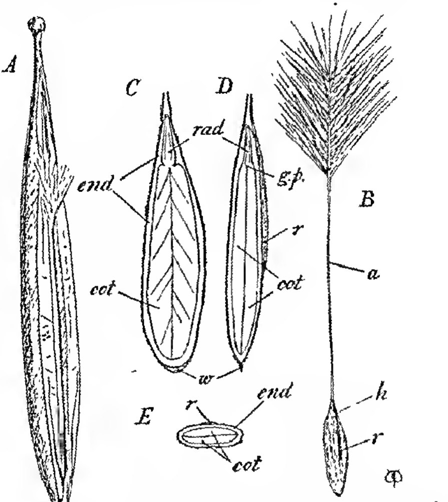


FIG. 67. Seed of *Strophanthus kombé*. *A*, follicle × ¼ *B*, seed, natural size. *C*, *D* and *E*, sections of the seed, all × 3. *a*, awn, *cot*, cotyledon; *end*, endosperm; *g p*, growing point of embryo, *h*, hilum; *r*, raphe; *rad*, radicle.

cotyledons lie face to face, filling the remaining space Both embryo and endosperm are very oily. The fracture of the seed is quite short and when the exposed surface is moistened with sulphuric acid, 80 per cent, the endosperm is coloured deep emerald green and the cotyledons also usually become green, but may sometimes develop a reddish colour. The odour is slight and unpleasant; the taste is bitter. One hundred strophanthus seeds weigh about 3 to 4 gm.

Histology. The *epidermis* is composed of elongated polygonal tabular cells, about 50 to 100μ long and 20 to 30μ wide and high, the anticlinal walls being straight, thickened and lignified. The upper surface of each epidermal cell is extended as a unicellular trichome bent over so as to be appressed to the seed. The free part of the trichome is about 500 to 800μ long, and is strengthened by a single narrow strip of lignified thickening which extends along the entire length of the adaxial side of the trichome. This strip is connected with the ring-shaped thickening of the trichome base by struts of thickening which arise from it and converge to meet above in the point where the strip begins. The remainder of the testa consists of a narrow layer of more or less collapsed thin-walled parenchyma, in occasional cells of which *calcium oxalate* in clusters or broken crystals may be found, but such crystals are rare. The endosperm and embryo consist of moderately thin-walled parenchyma containing abundant fixed oil and aleurone grains.

Constituents. Strophanthus contains 8 to 10 per cent. of a glycoside, *k-strophanthin, to which the green coloration with sulphuric acid is* due. The seeds also contain about 30 per cent. of fixed oil, together with kombic acid, strophanthic acid, choline, and trigonelline. They yield about 4 per cent. of ash on incineration.

Strophanthic acid is an acid saponin.

Uses. The action of strophanthus seed, which is due to the strophanthin they contain, resembles that of foxglove leaves. It raises the blood-pressure, is an efficient diuretic, and a powerful cardiac poison. It is not cumulative, and less liable than foxglove to produce gastro-intestinal irritation; hence it is sometimes substituted for foxglove when this remedy has failed or disagreed.

Substitutes and Adulterants. The seeds of *S. kombe often occur in* commerce mixed with, or replaced by, the seeds of other species of *Strophanthus* which resemble them more or less closely. The following are the most important:

S. hispidus de Candolle. This plant occurs in Senegambia, Sierra Leone and the lower Congo territory. The seeds are smaller than those of *S. kombe*, although similar in shape, brownish in colour, almost glabrous because the trichomes are easily rubbed off by mutual friction of the seeds and give with sulphuric acid a green coloration. They contain *h*-strophanthin. Neither the seed coats nor the embryo contain appreciable amounts of calcium oxalate.

S. Courmontii Sacleux. The plant is found in Zanzibar, Mozambique and Nyassaland; the seeds usually have a brownish tinge, but often closely resemble the official, from which, however, they may be distinguished by their rather smaller size, lanceolate shape, less bitter taste, red to violet reaction with sulphuric acid, and prismatic calcium oxalate crystals in the seed-coat. The active constituent is unknown. The seeds are said to be about one-fourth as active as Kombe seeds.

S. Nicholsoni Holmes. The plant is found in British Central Africa. The seeds are whitish and woolly, the trichomes form a tangled surface covering, and sulphuric acid colours the kernel red; *there are no crystals* of calcium oxalate in either seed-coat or embryo. The active constituent is unknown. This seed is sometimes known as "woolly strophanthus."

S. gratus Franchet. The plant grows in Sierra Leone, Cameroon and Gaboon; the seeds are brown and appear glabrous to the naked eye, but under the microscope short warty hairs are visible; the edges are acute;

neither seed coats nor embryo contain calcium oxalate; they give a rose-red coloration with sulphuric acid, and contain the crystalline glycoside ouabain, which was first isolated from the wood of *Acokanthera Schimperi* Oliver, and is much more toxic than strophanthin. For this glycoside the distinctive name of "*g*-strophanthin" has been proposed (Thoms, 1900); 100 seeds weigh 3 25 gm.

S. Emini Aschers. British Central Africa. The seeds are greyish-green, and closely resemble those of *S. kombe*; neither the seed-coat nor the embryo contains crystals of calcium oxalate, but they give a red to violet reaction with sulphuric acid. They contain the glycoside *e*-strophanthin (Thoms). They are medicinally active.

S. sarmentosus de Candolle. Senegambia, Sierra Leone, the lower Congo. The seeds resemble those of *S. kombe*; the colour varies from reddish-brown to greenish; the yellowish hairs easily break off; the seed-coat contains prisms, clusters and conglomerate crystals and the cotyledons contain abundant cluster crystals of calcium oxalate; reaction with sulphuric acid pale rose-red.

LINSEED. Flax Seed, Semina Lini. Linum

Sources. Linseed is the seed of the flax plant, *Linum usitatissimum* Linn., family Linaceæ. Flax seeds, as well as cloth woven from flax, have been found in Egyptian tombs, and the process of weaving is depicted on their buildings. The seeds were used as a food; the medicinal use of the mucilage and the value of the oil appear not to have been known till later.

Linseed is now chiefly produced in Argentina, Russia, Canada, India, the United States and Holland.

Cultivation and Collection. The cultivation of the plant has been described under Flax, see p. 37. After the "rippling" process, the seeds are separated from the husks by threshing and winnowing the fruits. In some places, the flax is pulled and made into sheaves which stand in stooks in the field to dry off and then the seed is threshed out by machinery similar to that used for crops of grain.

Description. The fruit of the flax plant is a small dry sub-spherical capsule, about 5 to 7 mm. in diameter, containing ten seeds in its five loculi. The seeds are about 4 to 6 mm. long, 2 to 3 mm. wide and 1·5 mm. thick; they are elongated-ovoid, somewhat flattened and have one edge more acute than the other. The proximal end of the seed is pointed and the hilum is in a slight hollow on the more acute edge close to the pointed end. The raphe extends as a yellowish line along the acute edge from the hilum to the distal end of the seed which is rounded. The thin testa is dark brown, finely pitted, smooth and shining. Within the testa is a narrow endosperm surrounding a straight embryo, composed of two large plano-convex cotyledons and a radicle directed towards the hilar end. The seeds are almost odourless and have a mucilaginous taste which becomes oily when they are chewed. When soaked in water the mucilage of the epidermis swells to form [illegible] seed.

T [illegible] weigh about 0 9 t [illegible] weigh about 0·4 to 0·54 gm.

Histology. The *epidermis* consists of polygonal tabular cells about 30 to 45μ in length and breadth and about 50μ in height; their anticlinal walls are thin and the lumen is filled with a stratified mucilage within which a few starch granules are sometimes enclosed; the inner tangential walls are suberised and the outer wall has a very thin cuticle. The sub-epidermal layer, sometimes named the *round-celled layer*, consists of one or more

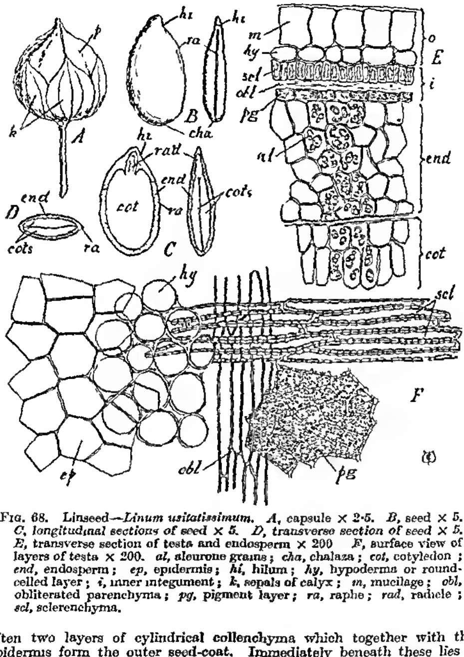


FIG. 68. Linseed—*Linum usitatissimum*. *A*, capsule × 2·5. *B*, seed × 5. *C*, longitudinal sections of seed × 5. *D*, transverse section of seed × 5. *E*, transverse section of testa and endosperm × 200. *F*, surface view of layers of testa × 200. *al*, aleurone grains; *cha*, chalaza; *cot*, cotyledon; *end*, endosperm; *ep*, epidermis; *hi*, hilum; *hy*, hypoderma or round-celled layer; *i*, inner integument; *k*, sepals of calyx; *m*, mucilage; *obl*, obliterated parenchyma; *pg*, pigment layer; *ra*, raphe; *rad*, radicle; *scl*, sclerenchyma.

often two layers of cylindrical collenchyma which together with the epidermis form the outer seed-coat. Immediately beneath these lies a single layer [illegible] each about 120 to 190μ [illegible] a thin multiple *hyaline laye*[illegible] inner epidermis formed of flat sub-rectangular to polygonal tabular cells, about 20 to 50μ in diameter, each containing a mass of *dark brown pigment*. The outermost

of the hyaline layers is composed of narrow elongated cells having their long axes at right angles to those of the sclereids. The narrow *endosperm* and the *embryo* consist of polyhedral cellulosic parenchyma containing [illegible] *grains* have a well-developed [illegible] 8 to 15μ in diameter. A few [illegible]

Constituents. Linseed contains from 30 to 40 per cent. of fixed oil, about 25 per cent. of proteins, about 4·5 to 9 per cent. of mucilage and a small amount of a cyanophoric glycoside, linamarin, which is [illegible] galactose, dextrose, arabinose and xylose. Small seeds contain a larger proportion of mucilage than large seeds, and are therefore to be preferred when mucilage is the constituent required. Unripe seeds contain numerous small starch grains, but the ripe seeds are free from starch. Ash about 3 to 4·5 per cent.

Oleum Lini, the fixed oil, consists chiefly of linolein, a mixture of the glyceryl esters of linolic, linolenic, and isolinolenic acids, the acids them- [illegible]

Uses. Whole linseed is used to make a demulcent drink by boiling the [illegible]

Crushed linseed, Linum Contusum, consists of the seeds reduced to a coarse powder without being deprived of any part of their constituents. It should, when mixed with water, have a bland, not pungent (Cruciferous seeds) or rancid (stale linseed) odour. It should yield not less than 30 per cent. of oil to ether (indicating the absence of ground cake left after removal of part of the oil), and the oil thus extracted should respond to the tests for linseed oil. It should not give the characteristic reactions with the tests for starch, or leave, when incinerated, more than 5 per cent. of ash (absence of added starch and undue proportion of mineral matter). The presence of starch may be conveniently detected by microscopical examination or by applying the usual iodine test to a cooled decoction of the crushed linseed previously freed from oil by treatment with ether.

Uses. Crushed linseed is used externally, in the form of a poultice, to [illegible] eeds, the [illegible] eed seeds [illegible]

QUINCE SEEDS. Semina Cydoniæ

Sources, etc. The quince is the fruit of *Pyrus Cydonia* Linn., family Rosaceæ, a small tree indigenous to Persia, but distributed by cultivation throughout central Europe and other warm countries; the seeds are imported chiefly from Cape Colony.

The fruit, which resembles a pear, contains five carpellary cavities, in each of which there are about twenty seeds closely packed in two vertical rows. These seeds are separated from the ripe fruit and dried; being coated with mucilage they adhere more or less firmly together.

Description. Quince seeds are obovoid and flattened, about 5 to 10 mm.

long, 2 to 5 mm. wide and 2 mm. thick. The two larger flattened surfaces meet in a straight acute edge on one side and are united by a strongly arched rounded surface on the other side. They frequently adhere to one another in small irregular masses or in two more or less regular rows, being cemented together by dry mucilage, which is visible in the form of whitish flakes on the surface of the seeds. This mucilage is derived

FIG. 69. Quince seed. *A*, the seeds cemented together by mucilage, natural size. *B*, a single seed, natural size. *C*, the same, softened in water, × 3. *D*, transverse section of *B*. *E*, portion of the same, × 190. *a*, the epidermis, in which the mucilage is secreted; *v*, endosperm; *r*, outer seed-coat; *y*, fibro-vascular bundle; *4*, cotyledon. (Berg.)

from the cells of the epidermis of the seed-coat. The seeds are pointed at

brown testa is a very narrow endosperm surrounding a straight embryo composed of two plano-convex whitish cotyledons and a small radicle. The kernel possesses a taste resembling that of bitter almonds but much fainter. The seed-coats, when chewed, are mucilaginous.

Constituents. The principal constituent of quince seeds is the mucilage, of which they are said to yield as much as 20 per cent. It is contained in the cells of the outer epidermis of the seed-coat, and swells and dissolves when the seeds are soaked in water. The seeds also contain about 15 per cent. of fixed oil and probably a small proportion of amygdalin and of emulsin, since they evolve an odour resembling that of bitter almonds when they are crushed and mixed with water.

Uses. Quince seeds have been employed as a demulcent, but are now more commonly used for making setting lotions and other toilet preparations.

SESAME SEED. Gingelly Seed, Teel Seed, Benne Seed

Sources. Sesame seed is the seed of *Sesamum indicum* Linn., family Pedaliaceæ, believed to be indigenous to tropical Africa and cultivated in India, China, Nigeria, etc.

Cultivation and Collection. The plant is an annual and is raised from seed sown broadcast on a sandy loam, the seeds are ripe at the end of about five months. The plants are then cut down, made into stooks to dry and the seed is shaken from the capsules. The white-seeded variety yields an oil suitable for medicinal purposes and for food; the black-seeded variety *S. orientale* DC. yields an oil used for industrial purposes.

Description. The seeds are flattened ovoid, pointed at one end, about 3 to 4 mm. long, 2 mm. broad and 1 mm. thick, buff coloured or whitish, finely punctate with four delicate longitudinal ridges at the edges of the flat faces;
as a line al
endosperm
plano-convex cotyledons and a small radicle.

Histology. The epidermis is the most characteristic feature; it consists of a thin-walled palisade, the anticlinal walls being more or less wavy;
exceptic
mass of
The rer
membrane on the inside. The tissue of the endosperm and cotyledons consists of cellulosic polygonal parenchyma containing fixed oil and small
Starch is absent.
oil 45 to 55 per cent., proteins
t. The oil consists of glycerides of oleic, linoleic, palmitic, stearic and myristic acids and also contains a crystalline substance, sesamin, and a phenolic substance sesamol, which gives the red colour with a 1 per cent. solution of sucrose in strong hydrochloric acid.

COCOA SEEDS. Semina Theobromatis

Source, etc. The cocoa tree, *Theobroma Cacao* Linn., family Sterculiaceæ, is a native of tropical America, and is cultivated there as well as in other tropical countries, the bulk of commercial cocoa coming from the Gold Coast, Nigeria, Ecuador and Brazil.

The seeds had long been an important article of diet to the Mexicans when they were conquered by the Spaniards. Their use soon spread to Spain and thence over Europe.

Collection and Preparation.
from the trunk; they are succe
the shape of a pointed vegetal
Each fruit contains forty or fift

in a scanty, mucilaginous pulp. The seeds are separated and packed in boxes, in which they undergo a process of fermentation, considerable heat, which, however, should not be allowed to exceed about 42°, being developed; they are then dried in the sun. During these processes the seeds acquire a reddish-brown colour, and the taste, at first astringent and bitter, becomes mild and oily. Sometimes the seeds are simply freed from the pulp and dried in the sun; they have then a more astringent and bitter taste and are less valuable.

Description. Cocoa seeds, are flattened-ovoid, about 20 to 30 mm. long, 15 mm. wide and 7 mm. thick. The seed-coat is reddish-brown or chocolate-brown in colour, thin and brittle. It can easily be separated from the kernel, which consists mainly of two irregularly folded, chocolate-coloured cotyledons; the latter easily separate into small angular fragments (cocoa nibs of commerce).

Constituents. Both the kernels and the shells contain the alkaloid theobromine, the former yielding usually from 1·2 to 1·7 per cent., the latter from 0·19 to 2·98 per cent., the theobromine being brought into the shell by the sweating that occurs during the process of fermentation (Wadsworth, 1922). Whether the theobromine is present in the fresh seeds as an unstable theobromine-tannin glucoside requires investigation. The kernels contain, further, about half their weight of solid fat, which is obtained as a by-product in the manufacture of cocoa essences by submitting the heated seeds to strong pressure (Oleum Theobromatis). The seeds also contain traces of caffeine and of volatile oil.

Oleum Theobromatis is obtained as a by-product in the manufacture of cocoa and chocolate. The seeds are first roasted, then broken and the shell removed; the resulting cocoa nibs are ground and subjected to hot [illegible] It forms [illegible] chiefly of [illegible] is existing [illegible] or more of these acids are combined with one glyceryl group.

Uses. Cocoa is largely used as a more nutritious and less stimulating [illegible] theobromine, [illegible] vous [illegible] also used as a vehicle for some worm remedies and in the manufacture of certain compressed tablets.

STRAMONIUM SEEDS. Thornapple Seeds, Semina Stramonii

Sources. Stramonium seeds are the ripe seeds of *Datura Stramonium* Linn., family Solanaceae. They come chiefly from southern England and central Europe.

Fig. 70. Thornapple seed. Showing the pitted surface, × 12.

Collection. The fruit of stramonium is an ovoid, thorny capsule about 3 to 3·5 cm. long, it is four-celled in the basal part, but has only two cells, corresponding to the two carpels, in the upper part. It dehisces septifragally to form four valves, see Fig. 123, p. 286, to liberate the numerous seeds. The capsules are gathered just before they split and the seeds ripen off inside the capsules which are dried at ordinary temperature in a dry airy room. The seeds are separated by sifting.

Description. The seeds are flattened and are reniform in outline, the concave or straighter edge being more acute than the strongly curved

convex edge which is rounded. They are about 3 to 3·7 mm. long, 2·5 to 3 mm. wide and 1 to 1·6 mm. thick. The testa is nearly black or dull dark brown and is marked by indefinite shallow reticulate depressions about 0·3 mm. wide and the whole surface is in addition finely pitted, the pits corresponding to the cells of the epidermis. The hilum is present on the acute edge near the narrower end of the seed. The interior of the seed is

somewhat unpleasant odour and the taste is bitterish and oily.

Constituents. Stramonium seeds contain 0·16 to 0·22 to 0·5 per cent. of total alkaloid consisting of hyoscyamine with traces of scopolamine (hyoscine) and possibly of atropine. Other constituents are proteins and

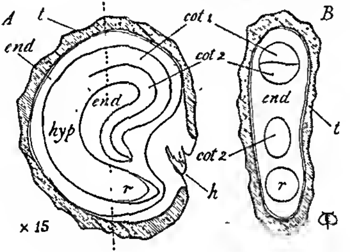


Fig. 71. Seed of *Datura Stramonium* Linn. *A*, longitudinal section parallel

about 15 to 30 per cent. of fixed oil containing glycerides of daturic and other acids. The drug yields from 2 to 3 per cent. of ash.

Uses. The properties of stramonium seeds resemble those of the herb. An extract of the seeds is given in spasmodic affections of the respiratory organs.

DATURA SEEDS. Daturæ Semina

Source, etc. Datura seeds are the seeds of *Datura Metel* Linn. family

encloses a curved embryo similar to that of stramonium seeds; they have a bitter taste but no odour.

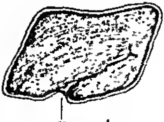
Constituents. The seeds contain the alkaloid scopolamine (hyoscine), about 0·2 per cent., and traces of hyoscyamine and atropine; they also contain resin and fixed oil.

Uses. Used in India as an equivalent of stramonium seed.

FENUGREEK SEEDS. Semina Fœni-græci

Sources, etc. Fenugreek, *Trigonella Fœnum-græcum* Linn., family Leguminosæ, is an annual herb indigenous to the countries bordering on the eastern shores of the Mediterranean and largely cultivated in India, Egypt, and Morocco; the seeds are imported chiefly from Mogadore and Bombay. It was well known to the ancients, who used the herb as cattle fodder and employed the seeds medicinally. In Egypt the seeds are roasted and eaten, and in India the young shoots form a favourite vegetable. They are contained in long, narrow, sickle-shaped pods, from which they are separated, when ripe, by thrashing.

Description. Fenugreek seeds are about 4 to 6 mm. long, 2 to 3 mm. wide and 2 mm. thick; they are hard, yellowish-brown, irregularly rhomboidal in outline and flattened. Nearly in the centre of one of the long, narrow sides is a small depression in which both hilum and micropyle are situated, the former appearing as a whitish point; this depression is continued in the form of a furrow running diagonally



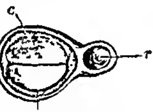


Fig. 72. Fenugreek seed. *A*, vertical section, showing the radicle, one of the cotyledons, and hilum, *n*. *B*, transverse section, showing the radicle, *r*; both cotyledons, *c*; and endosperm, *e*. × 5. (Moeller.)

being accumbent. The embryo is yellowish and the cotyledons are surrounded by a scanty, horny, dark, translucent endosperm. Soaked in water the endosperm swells and yields mucilage to the surrounding liquid. The odour of fenugreek, ... and spicey; ...

Constituen.. cent. of muc ... sperm; it yields by hydrolysis the sugars mannose and galactose. The drug contains, further, about 22 per cent. of proteins, 6 per cent. of fixed oil, a saponin and two alkaloids, trigonelline, and choline.

Uses. The seeds are now used in veterinary medicine and occasionally as a spice in curry powders.

STAVESACRE SEEDS. Semina Staphisagriæ

Sources, etc. Stavesacre, *Delphinium Staphisagria* Linn., family R... Italy.

Stavesacre was well known to both the Greeks and the Romans. Dioscorides mentions it, and Pliny describes its use as a parasiticide. It continued to be extensively employed throughout the Middle Ages, but is now in much less demand.

The fruit consists of three follicles, in each of which a few seeds are closely packed; these are collected when ripe.

Description. The seeds are about 5 to 7 mm. long and 3 to 6 mm. in width and thickness; the testa is dark brown, covered with obscure reticulations and is finely papillose. They are quadrangular ovoid in shape and pointed at the narrower end, the hilum being visible as a short line

near the apex. The embryo is small and straight and situated in the abundant oily endosperm, near the pointed end, towards which the radicle is directed. The kernel is translucent-white to yellowish in colour. The seeds are almost odourless; the seed-coat is nearly tasteless, but the kernel is intensely bitter and acrid.

Note. The large size of stavesacre seeds distinguishes them from the seeds of other species of *Delphinium*.

FIG. 73. Stavesacre seed, entire and cut longitudinally, showing embryo. × 2. (Maisch.)

Constituents. The seeds contain several alkaloids (in all about 1 per cent.), the most important of which are delphinine, delphisine, and delphinoidine; less important are staphisagroine, of which traces only are present, and staphisagrine, which is probably a mixture.

The seeds also contain from 30 to 35 per cent. of fixed oil, which may be extracted either by expression (expressed oil of stavesacre) or by solvents such as petroleum spirit, etc. In either case the oil carries with it the greater part of the alkaloids, including practically all the delphinine; these may be removed from the oil by shaking it with an aqueous solution of tartaric acid. Ash 10 to 13 per cent.

Uses. Stavesacre seeds are extremely poisonous, delphinine and delphinoidine resembling aconitine in action, but being weaker; the seeds are used as a parasiticide, chiefly in the form of ointment, the expressed oil, the powdered seeds, or an acid aqueous extract containing the alkaloids. Delphinine has also been employed both internally and externally for neuralgia, etc.

COLCHICUM SEEDS. Semina Colchici.

Sources, etc. The meadow saffron, *Colchicum autumnale* Linn., family Liliaceæ, is widely distributed over Europe, and abundant in some parts of England in moist meadows and pastures, especially in limestone districts, notably in Gloucestershire, Hampshire, Oxfordshire and Warwickshire.

Collection and Preparation. The lilac or pale purple flowers, about 15 cm. high, appear from August to October and have the general appearance of the flowers of the crocus—hence the name autumn crocus often given to colchicum. No leaves are present and the superior ovary lies at the side of a corm 10 to 20 cm. below the ground level. The slowly developing fruit remains below ground during the autumn and winter. A rosette of three or four linear-lanceolate leaves, about 15 to 25 cm. long, develops in the spring and in its centre the capsular fruit is carried above ground by the lengthening of its stalk. The capsule eventually dehisces septicidally into three valves and liberates the numerous seeds, which ripen in June to July. The capsules are collected about the end of May to June before they have split open; they are conveniently dried by enclosing them in muslin bags and hanging them in a dry place until they dehisce and liberate the ripened seeds, which are separated by sifting. As the seeds ripen they darken in colour and become covered by a saccharine exudation, as much as 5 per cent. of glucose having been found upon them.

Description. Colchicum seeds are sub-spherical and about 2 to 3 mm. in diameter. The testa is dull and dark reddish-brown, minutely pitted and rough. Over the raphe, which extends for a quarter of the circumference of the amphitropous seed, there is a local enlargement, the strophiole, at the end of which is a pointed projection at the

hilum. The abundant endosperm is very hard and tough, somewhat yellowish and oily. In the endosperm near the surface of the seed, the small embryo is embedded. The embryo is straight and lies in a radial direction along a diameter in the plane of the strophiole and at right angles to the diameter passing through the hilum. The strophiole contains starch in simple and compound grains, individual grains being about 4μ in diameter. The endosperm is coloured yellow by strong hydrochloric acid, indicating the presence of colchicine. The seeds are odourless, but have an unpleasantly bitter taste. One hundred seeds weigh from 0·42 to 0·55 gm.

FIG. 74. Cevadilla seed. *a*, flower, magnified. *b*, stamen, magnified. *c*, fruit, magnified. *d*, *e*, fruit after dehiscence, natural size. *f*, *g*, *h*, *i*, seeds, natural size; *k*, *l*, *m*, enlarged; *n*, cut longitudinally. (Luerssen.)

Constituents. All parts of the plant contain the alkaloid, colchicine, which possesses feebly basic properties and can be extracted from acid solution by chloroform. The seeds contain from 0·2 to 0·8 per cent., but a good sample of the drug should yield not less than 0·5 per cent. The seeds also contain a resin, colchicoresin, and about 6 per cent. of fixed oil. They yield about 3 per cent. of ash.

Uses. Colchicum is chiefly used to relieve the pain and inflammation and shorten the duration of acute gout and certain gouty affections. Its action depends upon the alkaloid colchicine. Colchicine has a marked action upon plain muscle, especially that of the intestine, producing diarrhœa and vomiting. In large doses it causes death from failure of the respiration.

Adulteration. Colchicum seeds are said to be liable to adulteration by the fraudulent addition of glucose.

CEVADILLA SEEDS. Sabadilla Seeds, Semina Cevadillæ

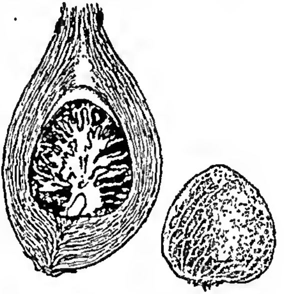
Sources, etc. Cevadilla seeds are the ripe seeds of *Schœnocaulon officinale* Asa Gray, family Liliaceæ, a tall herbaceous plant growing on the lower mountain slopes near the eastern coast of Mexico, in Guatemala, and in Venezuela. At the time of the Spanish conquest the drug was known to the American Indians as a caustic application to wounds; it came into use in Europe much later as a parasiticide. The seeds are now chiefly used as the source of veratrine.

The plant produces a tall raceme of yellowish flowers, succeeded by small three-celled capsular fruits; as the fruit ripens it separates septicidally into three follicles, which dehisce by their ventral sutures. Each follicle contains from one to six seeds. Formerly the dried fruits were imported, but now chiefly the seeds freed from the thin, brown, papery pericarps.

Description. Cevadilla seeds are glossy, dark brown or nearly black, about 6 mm. long, narrow and tapering to an acute point. From mutual pressure in the fruits there is usually on one side a longitudinal depression with acute edges; for a similar reason the seeds are slightly curved; the surface is finely wrinkled. The seeds are inodorous, but have an unpleasant, bitter, and acrid taste; the powder produces violent sneezing.

Constituents. The seeds contain several alkaloids of which cevadine, $C_{32}H_{49}NO_9$ (also called crystalline veratrine), is the most important and the most toxic; it is hydrolysed by alkalies yielding cevine and angelic, and tiglic acids. Veratridine (also called verarine) accompanies cevadine in the seeds; it is amorphous and yields veratric acid and verine when hydrolysed. Both cevadine and veratridine are toxic and sternutatory. Other alkaloids of less importance are sabadilline (cevadilline), sabadine and sabadinine. The seeds also contain chelidonic acid. *Commercial veratrine* is a mixture of these alkaloids and consists chiefly of cevadine and veratridine. Keller (1895) found 4·25 per cent. of alkaloid in the seeds.

Uses. Cevadilla seeds (and veratrine) act, both internally and externally, as a powerful irritant. Externally the irritation is followed by loss of sensibility; hence the ointment of veratrine is used to relieve neuralgic pains, etc. Veratrine is employed also as a parasiticide, but is seldom administered internally.



a *b*

FIG. 75. Areca nut. *a*, vertical section of the

ARECA NUTS. Betel Nuts, Semina Arecæ

Sources, etc. Areca nuts are the seeds of

The tree is widely

... and 2 to 3 cm. wide, are borne in large numbers on a branching axis. The pericarp is fibrous and surrounds a single seed, from which it is easily separated. The seeds are usually boiled in water with the addition of a little lime and dri...

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tannin; externally to the testa patches of a silvery coat are frequently attached, these being portions of the inner layer of the pericarp. In the centre of the basal part of the endosperm, the small embryo is situated and *an external paler area indicates its position. The seed has no odour, but* an astringent [illegible] bitter taste.

[illegible]

and the one to which the sialogogue and vermifuge properties of the seed are due, is arecoline (methylarecaidine). Other alkaloids are arecaidine, guvacine, guvacoline, and arecolidine).

Use. The powdered seeds are chiefly used in this country as a vermifuge for dogs.

GRAINS OF PARADISE. Guinea Grains, Grana Paradisi

Sources, etc. Grains of paradise are the seeds of *Aframomum Melegueta* Roscoe, family Zingiberaceæ, a herb attaining about 1·5 metres in height, indigenous to the west coast of Africa. These seeds were much esteemed as a spice in the twelfth and thirteenth centuries; the country from which they were derived being unknown, they were called "grains of paradise." At that time they were imported from Tripoli, whither they had made the land journey from West Africa. Subsequently they were brought direct from the west coast of Africa to Portugal. They are now imported from West Africa.

The plant produces an ovoid pointed fruit about 10 cm. long containing a large number of small seeds.

Description. Grains of paradise are inverted sub-pyramidal and somewhat four-sided with rounded angles and edges. They are about 2 to 3 mm. long and 2·5 mm. wide at the broad distal end. At the proximal end is a pale fibrous funicle forming a projecting point. The testa is rich reddish-

[illegible]

funicle. The odour of the crushed seeds is faintly aromatic and the taste is intensely pungent.

Constituents. Grains of paradise contain about 0·3 per cent. of volatile oil and a yellowish, extremely pungent, oily body, paradol. It resembles gingerol, but its pungency is not destroyed by boiling with 2 per cent. solution of caustic potash.

Uses. The seeds possess stimulant properties, and were formerly employed as a condiment; now they are chiefly used in veterinary medicine and as a domestic remedy for toothache, being applied as a small plaster.

NUTMEGS. Myristicæ Semina, Myristicæ, Nux Moschata

Sources and History. The nutmeg tree, *Myristica fragrans* Van Houtten, family Myristicaceæ, is indigenous to the Molucca Islands and a few neighbouring islands, as well as north-western New Guinea, but has been introduced into Penang, Sumatra, Malacca, Java, the West Indies, and Ceylon, nutmegs and mace being exported from the Malay Archipelago, the Straits Settlements, the West Indies, and Ceylon.

The use of the spice was introduced into Europe probably during the twelfth century. The Banda Islands, a group of the Molucca Islands, were discovered about 1506, and passed into the possession of the Portuguese, and finally of the Dutch, who, in this case as in that of cloves and cinnamon, made every endeavour to restrict the cultivation

of the nutmeg trees to the islands of Banda and Amboyna, and thus create a profitable monopoly. The nutmeg trees of adjacent islands were destroyed, and the nutmegs themselves soaked in a mixture of slaked lime and water to render them, it was said, incapable of germination, a precaution that was quite unnecessary, as the vitality of the seed is destroyed by the simple process of drying, it is quite

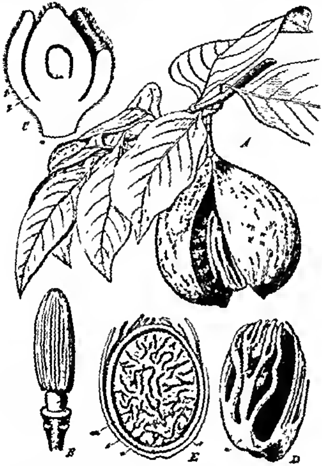

Fig. 76. Nutmeg. *A*, fruiting branch of *Myristica fragrans*, showing fruit dehiscing. *B*, stamens of staminate flower, magnified. *C*, pistillate flower cut longitudinally; *p*, perianth; *g*, ovary; magnified *D*, nutmeg surrounded by the arillus (mace). *E*, the same cut longitudinally; *e*, embryo; *a*, arillus; *s*, seedcoat; *en*, endosperm. (Luerssen.)

possible, however, that liming was intended to protect them from attack by insects. For some time these efforts were successful, and the nutmeg trade remained in the hands of the Dutch; but eventually the trees were successfully introduced into Malacca, Ceylon, and Jamaica.

Cultivation. The nutmeg tree needs a hot, moist climate with shelter from high winds and a well-drained rich loam for soil. The plants are raised from seed and when about a metre high are planted out about

9 to 12 metres apart each way. Bananas are grown between the young trees to afford suitable shade. The trees are diœcious and when they flower the sex is determined and male trees are removed so as to leave one for every seven or eight female. The trees begin to bear about the seventh year and two crops are taken each year, one in November to December and the other in April to June.

Collection and Preparation. The fruits are gathered in the morning, those higher up being removed by a stick provided with a hook and basket at its end. The light-yellow fruit is a drupaceous ovoid berry about 5 to 7 cm. long and 4 to 5 cm. wide; the fleshy pericarp splits longitudinally and the brown seed, surrounded by a crimson reticulate arillus, is removed. The arillus is stripped off and dried to form *mace*, while the seeds are dried in sheds on wickerwork trays supported about 3 metres above an earthen floor upon which a smouldering charcoal fire is kept burning during the night and is extinguished during the day, so that drying is continuous at a temperature not exceeding 60° C. The drying takes three to six weeks, during which the seeds are turned occasionally; when dry, the hard woody testa is cracked with a wooden mallet and the kernel removed. Before the final marketing nutmegs are "garbled," that is they are sorted according to size and wormy, immature and broken nutmegs are rejected. The sizes usually sold are 60 to 80, 85 to 95 and 100 to 125 to the pound.

Description. Nutmegs are ovoid, about 20 to 35 mm. long and 15 to 28 mm. wide. The kernel is greyish-brown externally and is marked with numerous minute dark reddish-brown points and lines; it is also reticulately marked with small furrows. This outer region is a thin layer of perisperm, which grows inwards into the endosperm at the position of the external furrows. The endosperm, which forms the bulk of the nutmeg, is greyish-brown and is ruminated by the ingrowths of the dark brown perisperm. At one end of a nutmeg is a small circular depression marking the position of the radicle of the embryo; before the removal of the testa the hilum was immediately adjacent to this mark. A groove, marking the line of the raphe, extends from the depression to the opposite end of the kernel where the chalaza is situated. The embryo lies in a small cavity in the endosperm and its cotyledons gradually grow up into the endosperm as they absorb the food it contains. The cut surface of a nutmeg easily yields oil when indented with the finger-nail. The odour is strong and aromatic and the taste aromatic and bitterish.

Histology. The thin perisperm, about 0·12 mm. thick, consists of a peripheral portion, sometimes described as primary perisperm, and an inner region, sometimes described as secondary perisperm. This inner perisperm grows into the endosperm to form the blunt ended ruminations, each of which usually contains a vascular bundle. The cells of the *peripheral perisperm* are polyhedral and much flattened, some of them contain single prisms of an unidentified crystalline substance, which is not calcium oxalate. The *inner perisperm* consists of thin-walled parenchyma and in each of its ruminations there is usually a vascular strand and numerous large oil-cells filled with the volatile oil. The *endosperm* is formed of a polyhedral parenchyma, the cells of which contain abundant fat, aleurone grains and starch grains. The *fat* is usually in the form of bunches of needle-shaped crystals; the *aleurone grains* are mostly small and irregular, but each cell usually contains one large grain with a well-developed crystalloid. The *starch* is in small rounded grains, about

2 to 5 to 10 to 20µ in diameter, occurring both singly and as compound grains of two to ten components. Scattered through the endosperm are tannoid cells with brown contents.

Constituents. The chief constituents of nutmegs are volatile oil (7 to 13 per cent.) and solid fat (about 25 to 30 per cent.); they also contain starch.

The volatile oil (sp. gr. 0·870 to 0·925; o.r. + 13° to + 30°) consists chiefly of terpenes together with myristicin, which possesses an intense odour of mace and passes over in the last portions of the distillate.

Myristicin, $C_{11}H_{12}O_3$, is crystalline and toxic; it is more easily absorbed in the presence of the other constituents of nutmegs and is less toxic to lower animals than to human beings.

Expressed oil of nutmeg is a yellowish, very aromatic solid, melting at 25° to 43°, now obtained from imperfect or broken nutmegs by means of a solvent; it contains about 12 per cent. of the volatile oil together with the glycerides of myristic, palmitic, and oleic acids.

Varieties. *Penang nutmegs* are broadly ovoid and very aromatic.

Singapore nutmegs are more deeply and minutely wrinkled and frequently show marks of scorching.

West Indian nutmegs are somewhat elongated and frequently have dark marks on them.

Uses. Nutmegs have stimulant and carminative properties; in large doses they are toxic, producing convulsions, an action due to the myristicin contained in them. The expressed and volatile oils have been used externally in chronic rheumatism.

Subs[illegible]
nutme[illegible]
nutme[illegible]
exported from New Guinea); this is longer, narrower and less aromatic than the official, and has a uniform, brown, scurfy surface and a distinctly acrid taste.

Bombay nutmegs from *M. malabarica* Lamarck are also long and narrow, but are destitute of aroma.

Factitious nutmegs, made from exhausted or damaged nutmegs mixed [illegible] several times [illegible] hereas genuine [illegible] ess volatile oil

MACE consists of flattened, lobed pieces about 25 mm. or rather more [illegible] oaked [illegible] It is [illegible] taste resemble those of nutmeg.

Mace contains from 4 to 15 per cent. of volatile oil which appears to be [illegible] d from the nutmeg. [illegible]-crystalline plates, [illegible] 68°) (Tschirch and [illegible]schlowsky, 1920).

V[illegible]

from that of genuine mace by the large amount of substances yielded to ether after previous exhaustion with petroleum spirit (30 per cent., as against 3·5 from genuine mace).

Macassar or Papua mace from *M. argentea* is in dull, brownish fragments with a dusty surface; the few, broad, widely separated lobes, ultimately unite to a compact cap; the taste is distinctly acrid.

CHAPTER XI

FRUITS

CONCURRENTLY with the development of the seed from the ovule, the ovary wall develops to form a case, named the **pericarp**, for the seeds, thus forming a fruit. The wall of the pericarp is usually divisible into three regions, viz., the epicarp on the outside, the endocarp on the inside and the mesocarp between them. The **epicarp** is usually the outer epidermis only, as in prunes, lobelia and *Capsicum minimum*, but may include also one or more modified hypodermal layers, as in colocynth. The **endocarp** similarly may be the inner epidermis only, as in *Capsicum minimum* and fennel, or it may consist of several modified layers as in the prune and olive, where it is developed as a thick woody structure forming the "stone" or casing of the seed. The **mesocarp** may be succulent as in the prune and tamarinds, or pithy as in colocynth or it may consist of several layers of different

was formed, had two or more loculi, these are found in the fruit and are separated by a septum or septa which are often membranous.

In a *superior* fruit the pericarp shows at the apex a small point-like scar where the style was attached, as in belladonna, or sometimes a strongly developed persistent stigma as in the capsule of a poppy. At the base of a superior fruit is found either the persistent calyx, as in belladonna and henbane, or scars left by the fall of the perianth parts from the thalamus, as in the poppy. In an *inferior* fruit the pericarp is surmounted by the persistent calyx and other remains of the perianth as in lobelia and pimento, or by scars left by the fall of the perianth parts as in vanilla. At the base an inferior fruit tapers directly into the pedicel

Sometimes other floral members such as the thalamus or sepals or other parts of the inflorescence, such as bracts or the inflorescence axis also undergo development and become enlarged or succulent and take part in the formation of fruits of more complex types known as aggregate and compound fruits.

Fruits therefore show a great diversity of structure and are com-

anise, aconite and the raspberry. A **compound fruit** is formed from a number of flowers closely grouped together, often from an entire inflorescence, examples are the fig. mulberry, long pepper and hops.

Histology. The outer and inner epidermises of the pericarp have the characters of epidermal structures in general and frequently possess stomata, usually in small numbers and those of the inner epidermis are often modified in form and in arrangement, as in the fruit of *Atropa Belladonna*, where the stomata have guard cells of fixed form, commonly

strongly crescent-shaped, with a very large open porus, the stomata being often arranged in small groups of two to four. Some of these groups consist of stomata which have no definite porus. In coriander certain cells of the **outer epidermis** contain well-formed solitary crystals of calcium oxalate; in pepper and cubeb each epidermal cell contains numerous small rectangular prisms. The **epicarp** of pepper and of cubeb consists of the epidermis and a hypodermal layer of sclereids and parenchyma. Colocynth has a more complex epicarp composed of the epidermis, a few layers of parenchyma and then several layers of lignified sclereids. The **inner epidermis** of the pericarp is often developed in a characteristic way. In the fruits of *Capsicum* it consists of parenchyma containing numerous large islands of lignified sclerenchyma, each island corresponding in extent to a [illegible]

cells, each group having arisen from a single mother-cell; these groups are often arranged with the long a[illegible] directions as are the blocks of a pa[illegible] endocarp is produced by the form[illegible] in the hypodermal region; when [illegible] as in the prune and the olive. In cubeb the sclereids are chiefly in a single layer; but in apples and currants there are several layers of elongated fusiform sclereids, the cells of successive layers crossing at a wide angle those of the layers above and below them, the whole forming a strong **cartilaginous membrane.** The **mesocarp** may be parenchymatous throughout excepting for the slender vascular strands present in its middle region; this condition is found in the prune and many other fruits. Sometimes lignified idioblasts occur in the parenchyma of the mesocarp as in lobelia. Very commonly sclereids occur in the mesocarp and may be scattered irregularly as in pimento or may be associated together to form a thick lignified layer in the middle of the mesocarp as in coriander. Frequently the mesocarp contains oil-cells as in laurel berries, cubeb and pepper, or oil-glands as in pimento, or oil-ducts as in many umbelliferous fruits such as fennel and dill. Associated with the vascular bundles laticiferous tissue sometimes occurs as in the capsule wall of *Papaver*, and in many fruits the cells of the mesocarp contain starch grains as in pepper.

Classification of Fruits

A. Simple Fruits.
  (i) Dry Fruits.
    Cremocarps: Caraway, Fennel, Ajowan, Dill, Cummin, Celery, Anise, Coriander, Hemlock.
    Legumes: Senna Pod, Tamarind, Cassia Pod.
  (ii) Succulent Fruits.
    Drupes and Drupaceous Fruits: Prune, Cocculus Indicus, Laurel Berries.
    Berries: Capsicum, Pimento, Colocynth, Bael, Orange, Lemon.

B. Aggregate Fruits.
  Of *Achenes*. Hips.
  Of *Follicles*. Star Anise.

C. Compound Fruits.
  Hops, Figs.

UMBELLIFEROUS FRUITS

Medicinal fruits derived from plants of the family Umbelliferæ are all of one type, known as a cremocarp. The cremocarp is a variety of schizocarp or splitting-fruit which divides into one-seeded portions each corresponding to one carpel; the carpel itself does not open to liberate the seed, hence these schizocarps are indehiscent fruits. The cremocarp consists of two carpels, each containing one seed, and is derived from an inferior ovary. At the summit of the fruit there may be five small inconspicuous sepals or a slight rim representing the calyx and in the centre are the two styles surrounded below by the disc-like nectary and forming the stylopod. When the fruit splits it divides vertically along the septum between the carpels, the two halves being termed mericarps. Each mericarp therefore has a flat surface, the commissural surface, and a rounded surface, the dorsal surface. From the central line of each commissural surface a fine thread separates, being attached basally to the pedicel and apically to the upper end of the mericarp. By the action of the wind or other disturbance the mericarps break loose from the carpophores and are scattered.

The seed in each mericarp is attached by its testa to the pericarp so that it completely fills the loculus. The seeds contain a small embryo at the apical end, embedded in an abundant oily endosperm. In the majority of these fruits there are schizogenous ducts extending through the mesocarp from base to apex; each duct is termed a vitta and the number and position of the vittæ are often characteristic of individual fruits. Usually there are two vittæ on the commissural surface and four on the dorsal surface. Between the vittæ the pericarp is ridged externally and a vascular strand is contained in each of these primary ridges. Between the primary ridges and over the vittæ there sometimes occur other ridges named secondary ridges. The ovules are anatropous and consequently on the commissural surface of each seed a fine vascular strand, the raphe, extends from base to apex in the central line of the testa, which is wider in that region than elsewhere. The number, distribution and arrangement of the vittæ and ridges afford valuable characters for the identification of individual fruits.

Umbelliferous fruits are usually classified according to the character of the seed. If the seed is flat on the inner or ventral surface, it is termed *orthospermous*, e.g., fennel; if it has a longitudinal groove on the ventral surface, it is termed *campylospermous*, e.g., hemlock; if it is concave on the ventral surface it is termed *cœlospermous*, e.g., coriander.

Classification of the Umbelliferous Fruits

Orthospermous

(a) Mericarp with six vittæ and five primary ribs.

(i) 8 to 10 mm. long and 2 mm. wide, greenish-brown or yellowish-brown. **Fennel.**

(ii) 4 to 6 mm. long and 1 mm. wide, dark brown with yellowish ribs, arcuate. **Caraway.**

(iii) 2 mm. long and 1 mm. wide, pale greyish-brown with pale prominences. **Ajowan.**

(b) Mericarp with six vittæ and five primary ribs, the lateral ribs being extended as wings.
   (i) Chocolate-brown with pale brown ridges. **Dill.**
   (ii) Brown with yellowish ridges. **Indian Dill.**

(c) Mericarp with five primary and four secondary ridges, emergencies and trichomes on epidermis. **Cummin.**

(d) Mericarp with six to twelve vittæ and five hardly prominent primary ridges; 1 to 1·5 mm. long. **Celery.**

(e) Mericarp with thirty to forty vittæ on the dorsal surface, epidermis with short, stiff trichomes. **Anise.**

Cœlospermous

Cremocarp 3 to 5 mm. in diameter. **Coriander.**

Campylospermous

Five prominent, crenated ridges on each mericarp; vittæ absent. **Conium.**

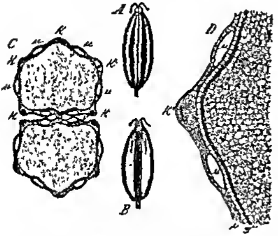

FIG. 77. Caraway fruit. *A*, entire fruit, side view × 3. *B*, longitudinal section × 3. *C*, transverse section · μ, vittæ; κ, ridges, × 14. *D*, portion of the same, further enlarged; ι, pericarp, τ, seed-coat. (Berg.)

CARAWAY FRUITS.
Fructus Carui

Source, etc. Caraway fruits are the ripe fruits of *Carum Carvi* Linn., family Umbelliferæ, an erect biennial herb distributed over central and northern Europe and found in Britain, but possibly only naturalised. It is cultivated principally in Holland, but Sweden, Norway, Russia, Germany, and Morocco also produce caraways, whilst a small quantity is grown in England.

Cultivation and Collection. Caraway is a biennial plant and is usually grown on a loamy soil. The seed is sown in March or April and the harvest is reaped in the summer of the following year at the end of August. Four or five seeds are put into each of the holes spaced about 25 cm. apart in rows, which have a distance of 50 cm. between them. A nitrogenous

sheaves are stacked in shocks on the field and allowed to dry which may take two or three weeks The fruits are finally separated in a threshing machine and are stored in bags made of a coarse fabric of jute or hemp and known as burlap bags. A cover crop is often grown during the first year, beans, white clover, flax, mustard or oats being suitable for the purpose. The full grown caraway plants are about 60 cm. high and have bipinnate leaves with linear segments.

Description. Commercial caraway is composed chiefly of separated mericarps, which are about 4 to 6 mm. long and 1 mm. broad and

thick. They are arcuate and taper towards base and apex to which half of the stylopod is attached. The outer surface is brown, the five primary ridges being yellowish. A transverse section of the mericarp is an almost regular pentagon in outline, the commissural side being slightly longer than the others. The fruit has the typical structure with six vittæ and five primary ribs in each mericarp, the entire cremocarp is somewhat laterally compressed. The odour and taste of the crushed fruits is agreeable and aromatic.

Histology. The epidermis is formed of polygonal-tabular cells, about 15 to 45μ across, with occasional stomata and a strongly striated cuticle. The mesocarp contains some finely pitted sclereids, but reticulate parenchyma is absent. The endocarp consists of elongated sub-rectangular cells, about 8 to 12μ wide, arranged parallel to one another. The seed endosperm is of the usual umbelliferous type, *i.e.*, it consists of moderately thick-walled cellulosic parenchyma containing fixed oil and aleurone grains. The aleurone grains are rounded and each usually contains one or sometimes two small rosette crystals of calcium oxalate. The carpophore consists chiefly of slender fibres Such small vessels, usually spiral, as are present do not exceed 20μ in diameter.

Constituents. Caraways yield by distillation from 3·5 to 7·0 per cent. of volatile oil, the principal constituent of which is carvone (50 to 60 per cent) They also contain proteins and fixed oil in the endosperm and yield about 6 (not over 9) per cent. of ash.

The *volatile oil* should have a sp. gr. 0·910 to 0 920 and o.r. + 70° to + 80°, from 53 to 63 per cent by weight should distil at a temperature over 200° Oil from which part of the carvone has been removed ("decarvonised" oil) has a lower sp. gr., lower optical rotation, and yields less than 50 per cent. boiling above 200°.

Adulteration. Caraway may be adulterated by exhausted fruits, by admixture of small stems and rays of the umbels and by Indian dill. *Exhausted caraways* are darker in colour, much shrunken and almost devoid of aroma; they may be detected in the powdered fruit by the low yield of volatile oil and of aqueous extract. *Caraway stalks* are detected in the powder by the abundance of sclerenchymatous elements and of vessels over 20μ in diameter and by the high crude fibre. *Indian dill* has much reticulate parenchyma in the mesocarp and the endocarp shows a parquetry arrangement.

Uses. Caraways, or the volatile oil obtained from them, are extensively used as an aromatic carminative.

FENNEL FRUITS. Fructus Fœniculi

Sources. Fennel, *Fœniculum capillaceum* Gilibert (*F. vulgare*, Miller), family Umbelliferæ, is apparently indigenous to the shores of the Mediterranean Several varieties of the plant are cultivated, *F. capillaceum* var *vulgare*, which is cultivated in Saxony and Wurtemberg and in Russia, Galicia and Roumania, yields fruits which are preferred in Britain and in Germany. *F. capillaceum* var *dulce* is cultivated in southern France and in southern Europe generally, and its fruits are preferred in those countries Fennel is also cultivated in India, Japan and other countries.

Cultivation and Collection. Seed, which should be of the most recent collection because it rapidly loses its vitality, is sown in the early spring. Four or five seeds are put into each hole at distances about 30 cm. apart in rows separated by about 60 cm. The plants grow to a height of 2 metres and are freely branched, so that they require plenty of space. The soil should be a light calcareous one, well-drained and in a sunny situation. Farmyard manure is applied liberally and in the second year the plants bear fruits which ripen in September. The stems are cut with a sickle and are put up in loose sheaves to dry in the sun. When dry the fruits are beaten out on a cloth in the sun and are cleaned by winnowing.

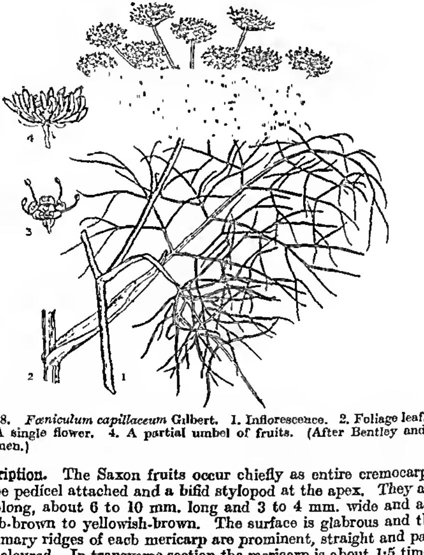

FIG. 78. *Fœniculum capillaceum* Gilbert. 1. Inflorescence. 2. Foliage leaf. 3. A single flower. 4. A partial umbel of fruits. (After Bentley and Trimen.)

Description. The Saxon fruits occur chiefly as entire cremocarps, with the pedicel attached and a bifid stylopod at the apex. They are oval-oblong, about 6 to 10 mm. long and 3 to 4 mm. wide and are greenish-brown to yellowish-brown. The surface is glabrous and the five primary ridges of each mericarp are prominent, straight and pale straw-coloured. In transverse section the mericarp is about 1·5 times as broad across the commissure as it is in thickness. The endosperm is orthospermous. Occasional abnormal fruits may possess six ridges and have correspondingly more vittæ and also sometimes one or two subsidiary vittæ on the commissure. They have an agreeable and aromatic odour and taste somewhat resembling that of anise.

Histology. The *epidermis* is composed of polygonal tabular cells about 15 to 30μ in length and width; it contains occasional stomata and the

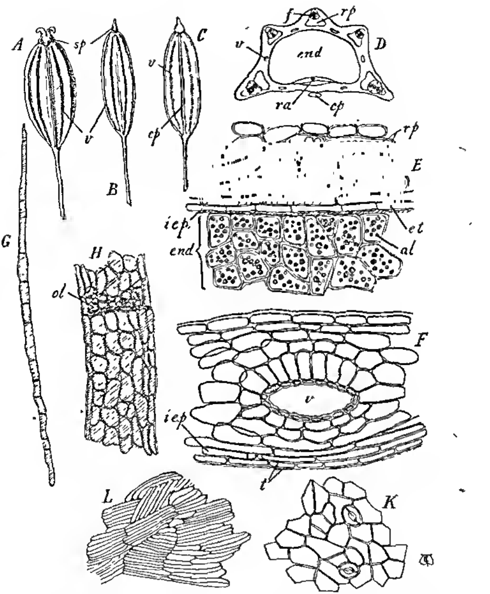

FIG. 79. Fennel fruit. *Fœniculum capillaceum.* *A*, lateral view of a cremocarp × 4. *B*, dorsal view of a cremocarp × 4. *C*, commissural surface of a mericarp × 4. *D*, diagram of a transverse section of a mericarp × 15. *E*, transverse section of part of pericarp within a vascular strand and of part of endosperm × 200. *F*, transverse section of pericarp including a vitta × 200. *G*, an entire vitta × 15. *H*, part of a vitta, showing segmentation and epithelium × 200. *L*, parquetry layer in surface view × 200. *K*, outer epidermis of pericarp × 200. *al*, aleurone grain; *cp*, carpophore; *end*, endosperm; *e.t*, epidermis of the testa; *f*, fibres; *i.e.p.*, inner epidermis of pericarp; *ol*, volatile oil; *ra*, raphe; *r.p.*, reticulate parenchyma; *sp*, stylopod; *t*, testa; *v*, vitta.

cuticle is not striated. The *mesocarp* contains much thickened and lignified parenchyma in the region of the vascular strands of the ribs. These thickened cells have large oval or rounded pits, the bands of thickening between them giving a reticulate appearance to the walls. The remaining parenchyma of the mesocarp is composed of ordinary polyhedral cellulosic cells. The *vittæ* are about 250μ in maximum width and taper towards base and apex of the fruit; the walls are brown and each duct is divided into chambers by transverse partitions. The vitta is lined by an epithelium of small polygonal-tabular cells. The *endocarp* consists of narrow elongated cells having a parquetry arrangement and appearing in transverse sections of the fruit as long narrow rectangular cells with here and there groups of very short cells, owing to the different directions in which the groups of cells in the parquetry have been cut. The *endosperm* has the structure characteristic of umbelliferous fruits in general.

Constituents. The best varieties of fennel (Saxon, Galician, and Russian) yield from 4 to 5 per cent. of volatile oil (sp. gr. 0·960 to 0·980, *o.r.* + 6° to + 12°; solidifying-point 5° to 20°), the principal constituents of which are anethol ($C_{10}H_{12}O$, 50 to 60 per cent.) and fenchone ($C_{10}H_{16}O$, 18 to 20 per cent.). The fruit contains 12 to 18 per cent. of fixed oil.

Fenchone is a colourless liquid possessing a pungent, camphoraceous odour and taste; it probably contributes materially to the medicinal properties of the oil, hence only such varieties of fennel as contain a good proportion of fenchone are suitable for medicinal use.

Varieties. The following are the chief commercial varieties of fennel fruits.

1. *Saxon*: as above described. Yield of oil 4·7 per cent., containing 22 per cent. of fenchone.

2. *Russian, Galician,* and *Roumanian*: these closely resemble one another; from 4 to 6 mm. in length and 1 to 2 mm. in width. Yield of oil from 4 to 5 per cent., of which about 18 per cent. is fenchone; taste very camphoraceous.

3. *French Sweet* or *Roman,* 7 to 8 mm. long, 2 to 3 mm. wide, often arched; pale yellowish green with a sweet, anise taste. Yield of oil 2·1 per cent., free from fenchone.

4. *Indian,* 6 to 7 mm. long, brownish, stalky, with sweet anise taste. Yield of oil 0·72 per cent., containing 6·7 per cent. of fenchone.

5. *Japanese,* 3 to 4 mm. long, 2 to 3 mm. wide, ovoid, not curved, pale greenish-brown in colour; taste camphoraceous and very sweet. Yield of oil 2·7 per cent., containing 10·2 per cent. of fenchone

6 *French Bitter,* 4 to 5 mm. long, 2 mm. wide, scurfy in the furrows, ridges less prominent, and colour darker than the sweet.

Adulteration. Fennel is subject to admixture with exhausted fruits. These include the fruits partially exhausted of their oil by distillation in a current of alcohol vapour in liqueur-making, as well as the residues obtained after distillation with water or in a current of steam. Fruits exhausted by water or steam are darker, contain less oil, and sink at once in water, but those exhausted by alcohol vapour retain 1·0 to 2·0 per cent. of oil, and are but little altered in appearance; they acquire, however, a peculiar fusel-oil odour. Recoloured fennel may be detected by rubbing the fruits between the hands.

Uses. Fennel is used as an agreeable aromatic and carminative.

AJOWAN FRUITS. The fruits of *Trachyspermum Ammi* (Linn.) Sprague (synonyms, *Carum copticum* (Linn.) Bentham and Hooker filius; *Ptychotis ajowan* (DC) Bentham and Hooker), family Umbelliferæ, India; ovoid, greyish-brown, about 2 mm. long, compressed, with pale-coloured short

protuberances; odour of thymol; mericarps usually separate. Six vittæ in each mericarp; the five primary ridges pale in colour. The volatile oil (3 to 4 per cent.) contains thymol (30 to 40 per cent.). Used as a source of thymol; in India as a spice.

DILL FRUITS. Fructus Anethi

Sources. The dill, *Anethum graveolens* Linn., family Umbelliferæ, is an erect annual herb growing to a height of 30 to 50 cm., indigenous to the Mediterranean districts and southern Russia; it is cultivated in England, Germany and Roumania.

Cultivation and Collection. The seed is sown very early in the spring in rows about 40 to 50 cm. apart on a well-prepared loam. The seedlings are thinned to 30 cm. apart in the rows and the crop is kept free from weeds. In the late summer, as soon as the oldest fruits are ripe, the crop is mown early in the morning and is put up in shocks to dry. After threshing, the fruits are spread out in a thin layer in the sun or in trays in a heated shed and turned at intervals until thoroughly dry.

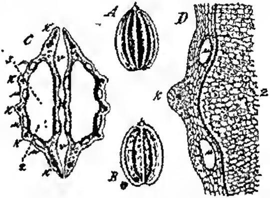

FIG. 80. Dill fruit *A*, entire fruit, side view, × 3 *B*, commissural surface of mericarp, showing the vittæ as dark lines × 3. *C*, transverse section: μ, vittæ; κ, ridges; ν, commissural surface; 2, endosperm × 14. *D*, portion of the same, further enlarged. (Berg.)

Description. Commercial dill consists chiefly of separated mericarps. Each mericarp is dorsally compressed, broadly oval and about 3 to 4 mm. long, 2 to 3 mm wide and 1 mm. thick, the ratio of length to breadth being about 1·6 to 1. The mericarp is chocolate-brown with wide yellowish membranous wings, which are the extended lateral ridges, and three brown, inconspicuous dorsal ridges. The transversely cut surface shows six vittæ and five vascular strands in the ridges, those in the wings being somewhat wider than the others. The seed is orthospermous.

Constituents. Dill fruit contains from 3 to 4 per cent. of volatile oil (sp gr. 0·900 to 0·915, o.r $+70°$ to $+80°$), consisting of carvone ($(C_{14})H_{10}O$, 40 to 60 per cent.), a colourless liquid with strong dill odour, and limonene associated with phellandrene and other terpenes.

Uses. Dill is employed as an aromatic stimulant and carminative, being given to infants to relieve flatulence.

Substitutes. Indian dill (*Anethum Sowa* Roxb) is imported in large quantities and used as a substitute for caraways when these are scarce. The fruits occur as entire cremocarps often with the pedicel attached. They are brown with narrow yellowish wings and three pale dorsal ridges; each mericarp is about 4 to 6 mm long, 2 mm. wide and 1·5 mm thick. The mericarps are oval and slightly dorsally compressed. The ratio of the length to the breadth is about 2·5 to 1. The volatile oil is different in

composition (sp. gr. 0·948 to 0·968; o.r. + 47·5° to + 50·5°, 40 to 50 per cent. … over 230 …, contains dillapiol which is poisonous) and the … used in place of European dill or of caraway.

CUMMIN FRUIT. Fructus Cumini, Cumin

Sources, etc. The cummin, *Cuminum Cyminum* Linn., family Umbelliferæ, is a small annual plant indigenous to the upper Nile territory, and cultivated in Morocco, Sicily, Malta, Syria and India. The fruits were well known to the ancients, and were much used in Europe in the Middle Ages as a culinary spice.

Description. Cummin consists of both separated mericarps and entire cremocarps, which latter are elongated ellipsoidal, dull fuscous, about 4 to 6 mm. long and 2 mm. wide and slightly compressed laterally. Each mericarp has five yellowish, straight primary ridges which bear very short trichomes or are glabrous, and between them (making the fruit rough to the feel) over the vittæ are four secondary ridges which bear bristly emergences. The transversely cut surface shows the typical structure with six vittæ in each mericarp and an orthospermous seed. Odour and taste aromatic, spicy and unpleasant.

Constituents. Cummin fruits yield from 3 to 4 per cent. of volatile oil (sp. gr. 0·972; o.r. + 25·5°; chief constituent cuminic aldehyde).

Uses. The fruits have been used as a stimulant and carminative; they are now chiefly employed in veterinary medicine.

Persian cummin is probably derived from a species of *Carum*; fruits smaller than cummin or caraway fruits; odour similar to cummin; oil contains no carvone.

CELERY FRUIT, Apii Fructus, Apium. Celery fruits are the dried ripe fruits of cultivated plants of *Apium graveolens*, family Umbelliferæ. They are imported chiefly from the Levant and southern Europe.

Description. Celery fruits usually occur as separated mericarps; the cremocarp is brown, roundish-ovoid, laterally compressed and about 1 to 1·5 mm. long, 1·5 mm. wide and 0·5 mm. thick. Each mericarp has five straight, scarcely prominent, primary ridges, and usually six to nine or sometimes twelve vittæ, two being on the commissural surface and from one to three in each vallecula. The seed is orthospermous.

Constituents. Celery fruit contains about 2 to 3 per cent. of volatile oil, also fixed oil, protein and some mucilage.

Uses. The fruits are used as a sedative and tonic and as a domestic remedy for rheumatism.

ANISE FRUITS. Aniseed, Fructus Anisi

Sources, etc. The anise, *Pimpinella Anisum* Linn., family Umbelliferæ, is an annual plant indigenous to Greece, Egypt, and Asia Minor; it is cultivated largely in southern Russia, also in Spain and Bulgaria. Aniseed is one of the oldest of medicines and spices; it was cultivated by the ancient Egyptians, and was known to Dioscorides and Pliny; in this country it has been in use since the fourteenth century. The drug consists

but little altered in a…
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…hands. …cremocarp is about 3 to 5 mm. long and 1·5 to
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Description. …UITS. The fr… …merous short, conical epidermal trichomes;
pedicels attached, … *copticum* (L… …rcate stylopod. Each mericarp has two,
2 mm. wide; it is … …ham and Ho… …tæ on the commissural surface and about
owing to the … …that 2
it is crowned b…
sometimes three…

twenty to forty small vittæ on the dorsal surface, the large number of vittæ having arisen by the branching of four original ducts.

Anise fruits possess a sweet aromatic taste, and exhale, when crushed, an aromatic odour.

Varieties. *Spanish*, exported from Alicante; the fruits are distinguished by their large size (4 mm), grey or brownish-grey colour, and slender tapering shape; they yield about 3 per cent. of oil.

Russian fruits are smaller, darker, and rather more ovoid in shape; they are exported in very large quantities, and are the variety generally used for distillation.

Italian anise fruits are frequently contaminated with *hemlock fruits*, which may be identified by their glabrous surface, by the irregularly crenate ridges, by the absence of the pedicel, and (best of all) by the deep groove in the endosperm.

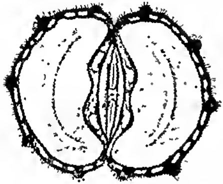


FIG. 81 Anise fruit. Transverse section, indicating the position of the vittæ, not all of which (about forty in each mericarp) are shown. Magnified. (Moeller.)

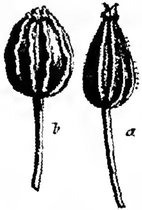


FIG. 82 *a*, Anise fruit. *b*, Hemlock fruit. Magnified (Vogl.)

Constituents. The fruits yield from 1·5 to 3·5 per cent. of volatile oil (sp. gr. 0·975 to 0·990; o.r. $-2°$ to $+1°$), of which anethol, present to the extent of about 90 per cent., is the principal aromatic constituent. Anethol, $C_{10}H_{12}O$, forms a white, crystalline solid melting at 22°; it has a strong anise odour. The fruits also contain proteins and about 8 to 11 per cent. of fixed oil.

Anise fruits are frequently adulterated with dried, sifted earth; the ash should not exceed 11 per cent.; in adulterated anise it may rise to 25 per cent. The normal ash is 7 to 8 per cent.

Uses. Anise is employed as an aromatic and carminative.

CORIANDER FRUITS. Fructus Coriandri

Sources, etc. The coriander, *Coriandrum sativum* Linn., family Umbelliferæ, is an erect herbaceous annual that has become naturalised throughout temperate Europe. It is cultivated principally in Russia, Thuringia, Moravia, and Hungary, as well as in northern Africa, Malta, and India. The whole plant, and especially the unripe fruit, is characterised by a strong disagreeable odour, whence the name coriander (from the Greek *κόρος*, a bug).

Cultivation and Collection. Coriander may be sown in March or soon after harvesting in the early autumn; the plants grow to a height of 45 to 60 cm. and are larger and more robust if the seed is sown in the autumn. A well-drained calcareous loam is a good soil and the plants are grown in rows about 50 cm. apart. The harvest is made in August and the umbels may be cut off with scissors as they become ripe or, for large fields, a scythe or mower may be used, the reaping being done early in the morning to avoid loss of fruit. Umbels are spread on sheets in the sun to dry off; cut plants are put up in small cocks on the field. After about forty-eight hours the crop is threshed and the separated fruits further dried in warm air in a shed. During the drying the fruits lose their objectionable fœtid odour and acquire a warm agreeable odour and a sweet taste.

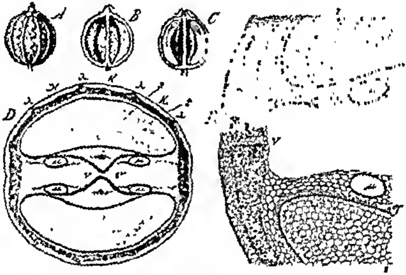


FIG. 83. Coriander fruit. *A*, whole fruit (cremocarp) × 3. *B*, commissural surface of half-fruit (mericarp), showing the vittæ as dark lines. *C*, longitudinal section through both mericarps, showing the endosperm and embryo × 3. *D*, transverse section, showing the vittæ, μ, × 14; *E*, portion of the same, further enlarged; κ, primary ridges; λ, secondary ridges; 2, endosperm. (*Berg.*)

Description. The fruits occur usually as entire cremocarps, which are sub-spherical, about 3 to 5 mm. in diameter, brownish-yellow, crowned by five small sepals and a stylopod. Each mericarp has five wavy rather inconspicuous primary ridges and four straight, more prominent secondary ridges. In the central region of the pericarp the cells are fusiform and sclerotic forming in each mericarp a thin hemispherical shell of compact hard tissue which makes the fruit difficult to cut and troublesome to powder. The seed is cœlospermous. The fruit has two vittæ on the commissural surface of each mericarp; in addition to these, however, the young ovary contains vittæ on the dorsal surface; as the fruit ripens these become compressed and break down into tangentially elongated cavities, the outer portion of the pericarp being finally thrown off. The odour of the bruised fruit is aromatic, and the taste spicy.

Histology. The epidermis of the pericarp is composed of polygonal

tabular cells with occasional stomata; several of the epidermal cells contain in each a single prism of calcium oxalate. The mesocarp is composed of an outer and an inner layer of parenchyma, between which is a layer of sclerenchyma consisting of fusiform, lignified sclerenchymatous cells in sinuous rows. The outer five or six rows of sclerenchyma run longitudinally while the inner one to three rows run tangentially; in the secondary ridges almost all the cells run tangentially. When seen in surface view this layer therefore shows a very characteristic appearance of sinuous rows crossing at right angles. The inner epidermis of the pericarp is composed of parquetry cells and the hypodermis of large, slightly thickened, flattened hexagonal sclerenchyma. The seed shows the structure characteristic of umbelliferous seeds in general. Trichomes and lignified reticulate parenchyma are absent.

Varieties. *English* corianders are considered to have the finest flavour, *Russian* and *German* are the richest in oil (up to 1·0 per cent.); *Mogadore* are the largest, but contain little oil.

Constituents. Coriander fruits of good quality yield from 0·8 to 1·0 per cent. of volatile oil (sp. gr. 0·870 to 0·885; o.r. + 8° to + 14°; chief constituent 90 per cent. of the alcohol linalol). That distilled from unripe fruit has a fetid odour, which, however, disappears on keeping.

Adulterants, etc. *Bombay* coriander fruits are ellipsoid, about 5 to 8 mm long and 3 to 4·5 mm. wide, and contain little volatile oil.

Fenugreek seeds, cereal fruits and similar small fruits and seeds are often present in commercial coriander.

Uses. The fruit and the oil distilled from it are used as aromatic carminatives.

HEMLOCK FRUITS. Fructus Conii

Sources, etc. The common or spotted hemlock, *Cōnium maculatum* Linn., family Umbelliferæ, is a biennial plant widely spread throughout temperate Europe and generally distributed over Great Britain.

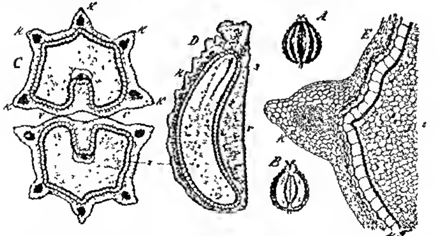


FIG 84. Hemlock fruit. *A*, side view of entire fruit *B*, longitudinal section of the same, showing endosperm and embryo, × 3 *D*, half of the same, further enlarged; 3, embryo. *C*, transverse section *v*, commissural surface; *κ*, ridges; 2, endosperm, × 14. *E*, portion of the same, further enlarged. *ι*, pericarp; *r*, seed-coat. (Berg.)

The fruits should be gathered from wild plants when full grown, but before they ripen—that is, before the colour changes from green to yellow—and thoroughly dried; if carefully preserved quite dry they will long retain their activity unimpaired.

Description. The cre [illegible] laterally compressed; [illegible] the summit is a small s [illegible] usually separate; each mericarp has five paler and prominent primary ridges, which are irregularly enlarged at intervals giving them a crenate or wavy appearance; the outer surface is glabrous. There are no evident vittæ in the pericarp and the inner epidermis is developed as a layer of cells containing the liquid alkaloid coniine and is often termed the "coniine layer." The endosperm has a deep longitudinal groove on the commissural surface, so that the fruit is campylospermous. A microscopical examination of a transverse section of the fruit reveals the presence of numerous small vestigial vittæ, which are visible only with difficulty. The fruit has scarcely any odour or taste, but when to the crushed fruit a dilute solution of caustic potash is added a strong mouse-like odour is developed owing to the liberation of coniine. See Fig. 84.

Constituents. The principal constituent of hemlock fruits is the poisonous, volatile, liquid alkaloid coniine, of which they may contain, when collected at the proper time and dried, as much as 2·77 per cent. (Farr and Wright, 1904), the average being 1·65 per cent.

The proportion of coniine present attains its maximum when the fruits are full or nearly full grown, but before the colour changes from green to yellow; during this change (the ripening of the fruit) the proportion of coniine rapidly diminishes; commercial fruits yield from 0·5 to 1·3 per cent. of coniine. It is accompanied in the fruit by small quantities of methylconiine, which is oily and resembles coniine, and by conhydrine, which is colourless and crystalline. Ethyl piperidine and pseudoconhydrine are also present.

Uses. Hemlock is used in spasmodic and convulsive diseases, such as tetanus, chorea, and epilepsy; in asthma, whooping-cough, and spasmodic affections of the larynx. Coniine depresses the medulla and motor nerve endings, excessive doses resulting in death from respiratory paralysis.

SENNA PODS. Sennæ Fructus. Senna Legumes, Senna Fruit

Sources. *Senna pods are the dried nearly ripe fruits of Cassia acutifolia* Delile (Alexandrian senna pods), and of *C. angustifolia* Vahl (Indian senna pods), family Leguminosæ. For geographical sources and method of collection, see under Senna Leaf, p. 120.

Description. *Alexandrian senna pods* are broadly reniform-oblong in outline, 4 to 5 cm. long, not less than 2 cm. wide and about 0·5 mm. thick. The pods are dull green or brownish-green and brown in the central line over the seeds; the dorsal suture has a strongly convex curvature and the ventral suture is slightly concave or sometimes nearly straight with a small point-like scar at the distal end, marking the place where the style has fallen off, and a linear scar about 1 mm. long at the proximal end of a short stalk. Veins run from both sutures towards the central line where they unite by fine anastomosing branches. The inner surface of the valves forms a tough thin endocarp with a silky sheen, pale green in colour with brown areas over the seeds. The *seeds* are compressed parallel to the two broad green cotyledons; they are obovate-triangular in outline and the embryo is

embedded in a scanty greyish endosperm. Externally the testa is reticulately wrinkled and at the pointed end there is a longitudinal spathulate ridge about 2 mm. long on each flat face of the seed. The seeds are about 5 to 6 mm long, 3 to 4 mm. broad and 1·5 mm. thick, the hilum is at the pointed end and the filiform funicle is about 5 to 7 mm. long.

Tinnivelly senna pods resemble the Alexandrian pods in their general structure. They are about 5 to 6 cm. long and not more than 1·5 to 1·7 cm. wide; broadly oblong and scarcely curved. The colour is brownish-green and *darker in the centre over the seeds*. The *dorsal suture* is only slightly curved except at the extremities and the ventral suture is nearly straight. The *seeds* also resemble those of Alexandrian senna pods, but the wrinkling of the testa takes the form of irregular lines running transversely from the margins to the centre.

Constituents. The constituents are presumably the same as those of senna leaf.

Uses. Senna pods are used as a laxative and are considered to be more certain than the leaves and to cause less griping. The liquid extract made from the fruits (with seeds) appears to cause more pain than one made from the pericarps alone; the reason for this is not known.

Fig. 85 Fruit of the Tamarind tree with part of the pericarp removed, showing s, seed; f, fibres; p, epicarp, m, pulp Natural size. (Vogl.)

TAMARINDS. Fructus Tamarindi

Sources and History. The tamarind tree, *Tamarindus indica* Linn., family Leguminosæ, a large tree indigenous to tropical Africa, is cultivated throughout India and the West Indies, where it furnishes a valuable article of diet. The Arabian name of the fruit (Tamare Hindi, or Indian date) would indicate that the Arabians became acquainted with it from the Hindus, and introduced it into Europe.

Collection and Preparation. The tree bears erect racemes of flowers succeeded by indehiscent legumes about 5 to 20 cm in length and 2 cm in width. The epicarp of the legumes is rough, brownish, hard and brittle, the mesocarp is juicy and acid, and traversed by a few stout, branching vascular bundles. The endocarp is coriaceous and forms a series of one-seeded enclosures around the three to six (sometimes up to twelve) seeds, which are reddish-brown, obscurely quadrangular about 15 mm by 12 mm. and 4 to 6 mm thick.

In the West Indies tamarinds, exported from Barbados and Antigua, are collected when ripe, and prepared for the market by removing the epicarp, packing them in barrels, and preserving them by pouring over them boiling concentrated syrup which fills up the spaces and acts as a

preservative. In India the pulp is simply pressed into cakes, with or without the addition of 10 per cent. of salt as a preservative. Small quantities of tamarinds are also exported from other countries.

Description. West Indian tamarinds, which are those used medicinally in Great Britain, occur as a reddish-brown, moist, sugary mass, in which the vascular strands and reddish-brown seeds enclosed in the leathery endocarp can readily be found. The pulp has an agreeable odour and a sweet acidulous taste.

From India tamarinds are sent in the form of firm, black cakes consisting of the pulp of the fruit, together with the fibres, seeds, and small portions of the epicarp. Although not official, it is frequently employed, and yields a good pulp. The cakes have scarcely any odour, but a rather strongly acid taste.

Constituents. Tamarind pulp, though varying in composition, contains about 10 per cent. of free tartaric acid, about 8 per cent. of acid potassium tartrate, and from 25 to 40 per cent. of invert sugar. The total acidity varies from 11 to 16 per cent. West Indian tamarinds contain much add[illegible]

Uses. [illegible] and gentl[illegible]

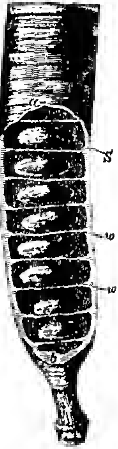


FIG. 86. *Cassia fistula.* Lower portion of a pod partly opened to show the seeds. *S*, seed; *w*, transverse dissepiments; *b*, pericarp of fruit. (Moeller, after *Wiesner.*)

CASSIA PODS. Fructus Cassiæ Fistulæ, Cassiæ Fructus, Purging Cassia

Sources, etc. Cassia pods are the ripe fruits of *Cassia fistula* Linn., family Leguminosæ, a tree of moderate size, indigenous to India, and often cultivated there as an ornamental plant (Indian laburnum). Purging cassia was known in Europe in the thirteenth century, and was used by the school of medicine at Salerno.

The tree bears pendulous racemes of fragrant flowers, each with a one-celled, many-seeded ovary, which develops into a long, cylindrical fruit. As the latter ripens the seeds become separated from one another by the formation of about 50 to 100 thin, transverse, spurious dissepiments, and the fruit, which was originally one-celled, becomes spuriously many-celled. It differs from a typical legume in being indehiscent as well as many-celled, and is described as a lomentaceous legume.

Cassia pods are imported from Dominica and Martinique in the West Indies and from Java. They are also cultivated in Egypt.

Description. The pods of commerce are 40 to 70 cm. long and 20 to 27 mm. in diameter, straight or slightly curved, sub-cylindrical, dark chocolate-brown, smooth but finely striated transversely, the striations appearing as fine fissures under a lens. The rounded distal end bears a small point or mucro, marking the position of the style, and the base or proximal end is extended as a short stalk widening below towards the remains of the thalamus. The dorsal suture appears as a single vascular

strand and the ventral suture as two closely applied strands. Internally the pod is divided by thin, buff-coloured, transverse dissepiments at intervals of about 0 5 cm. The compartments, each containing one seed, are filled in the fresh fruit with a nearly black pulp, which contracts on drying and adheres to the dissepiments. The seeds may become loose in the very dry pods, which then rattle when shaken. The 25 to 100 seeds of each pod are flattish and oval, reddish-brown with a well-marked raphe on one of the flattened sides, smooth, shining and about 8 by 10 by 2·5 mm. Each seed contains a whitish endosperm in which the yellowish embryo is embedded. The pulp has a sweetish taste and a somewhat sickly odour

Constituents. The pulp, which is the only part used medicinally, is separated by crushing the fruits, macerating them with water, straining the liquid, and evaporating it to a soft extract. It contains about 50 per cent. of sugar (calculated upon the pulp dried at 100°), and also oxymethylanthraquinones (1 09 per cent., Maurin, 1927); both of these probably contribute to its laxative action.

Uses. Cassia pulp is laxative, but is seldom used except as an ingredient in confection of senna.

Substitutes. Pods of *Cassia grandis* Linn. (horse cassia). Longer, thicker and heavier than those of *C. fistula*, about 50 to 80 cm. long and 4 to 9 cm. in diameter; laterally compressed; surface rough; one prominent ridge on the dorsal and two on the ventral suture; odour of pulp disagreeable, taste bitter and astringent.

Pods of *C. moschata* Humboldt, Bonpland and Kunth. Smaller and narrower than those of *C. fistula*, being about 15 mm wide; pulp paler, odour musk-like.

CARDAMOM FRUITS

Sources. Cardamom fruits are the dried, nearly ripe capsules of *Elettaria Cardamomum* Maton var *minuscula* Burkill, family Zingiberaceæ, a tall, perennial, reed-like plant that grows wild in the moist forests of southern India, especially near the Malabar coast, at heights of 600 to 1,000 metres above the sea-level. It is cultivated there as well as in Ceylon, the fruits of commerce being obtained from cultivated plants.

Cultivation and Collection. Seedling plants are raised in nursery beds. The seeds take about four months to germinate, and in the course of a year grow to a height of 30 cm. and bear from eight to ten leaves; they are then planted out in forest clearings in holes about 2 metres apart. A first small crop of fruit is available at the end of the third year and full crops in succeeding years. Racemes of flowers arise from the stem just above the ground level and the fruits are removed from the rachis as they become full grown, but are still unripe and somewhat green in colour. If left till they are ripe the capsules tend to dehisce during drying and liberate the seeds. The fruits are dried on raised trays in the open air, trimmed by machinery to remove pieces of stalk and the remains of the flower-parts, graded by sieves, sorted to colour and frequently bleached on trays over burning sulphur

The harvesting is done during August to October and much of the green cardamoms is dried in sheds by artificial heat. The fruits are spread on the ground level and also on a strong, raised, lattice-like floor, beneath which are two furnaces and their flues; the fruits take about thirty hours to dry.

Description. The fruit is an inferior capsule, about 1 to 2 cm. long, ovoid and more or less three-sided with rounded angles, greenish to pale buff or yellowish in colour. The *pericarp* is dry, about 0·5 to 1·0 mm. thick, and rather woody in texture. The base is rounded or has the remains of the pedicel, at the apex there is usually a slight projection consisting of the remains of the perianth. The capsule has three

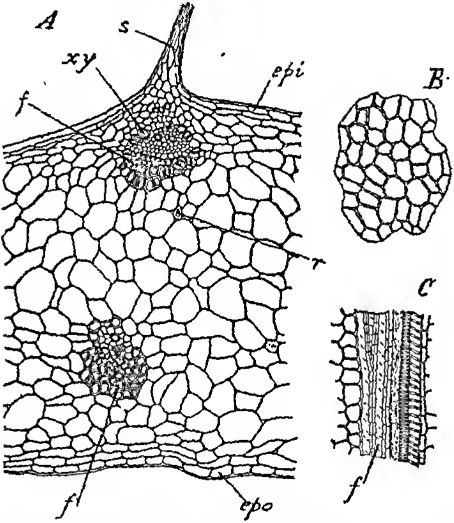


FIG. 87. *Elettaria Cardamomum* var. *minuscula*, pericarp. *A*, transverse section. *B*, epidermis in surface view. *C*, longitudinal section of vascular bundle; *epi*, inner epidermis; *epo*, outer epidermis; *f*, fibres; *r*, resin cell; *s*, part of dissepiment; *xy*, xylem. (After Tschirch and Oesterle.)

loculi with membranous septa and axile placentation; the seeds in each loculus, about five to eight in number, adhering together to form a single mass. Four important varieties are found in commerce :—

Mysore cardamoms coming from Ceylon, are ovoid, cream-coloured and bleached, with a nearly smooth surface.

Malabar cardamoms, also from Ceylon, are shorter, more broadly ovoid and somewhat wrinkled longitudinally and therefore less smooth than the Mysore variety.

Mangalore cardamoms from southern India are larger than the Mysore variety, more globular and with a roughish and almost scurfy surface.

Aleppy cardamoms are rather small, about the size and shape of the Malabar variety, but green in colour.

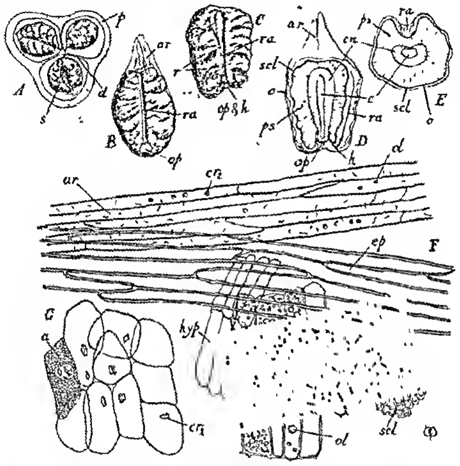


FIG. 88. *Elettaria Cardamomum* var. *minuscula*. *A*, fruit cut transversely × 3. *B*, seed covered by arillus × 5. *C*, seed without arillus × 5. *D*, longitudinal section of seed × 5. *E*, transverse section of seed × 5. *F*, surface view of layers of testa, all × 100. *G*, cells of perisperm × 150. *a*, starch; *ar*, arillus; cr_1, prism of calcium oxalate, cr_2, cluster of calcium oxalate, *d*, dissepiment, *e*, embryo; *en*, endosperm; *h*, hilum; *hyp*, hypodermis; *o*, oil layer; *ol*, oil droplet; *p*, pericarp; *par*, parenchyma; *ps*, perisperm; *r*, rugæ; *ra*, raphe; *s*, seed; *scl*, sclerenchyma

The *seeds* of cardamoms are about 3 mm. long, irregularly ovoid with flattened faces and rounded angles owing to mutual pressure. They are hard and are covered externally by a colourless membranous arillus which becomes thicker and oily in the fully ripened seeds. The raphe lies in a longitudinal groove running from the short funicle to the chalazal end. Beneath the arillus, the testa is dark reddish-brown and marked by about five to eight transverse wrinkles; unripe seeds are

pale yellowish-brown. Close to the funicle and opposite to the tip of the radicle there is a small operculum in the testa. The aril arises partly from the funicle and partly from the operculum. The kernel of the seed consists of an abundant white starchy perisperm in which is embedded a small yellowish endosperm surrounding a small straight and almost cylindrical embryo, which is about 1·5 mm. long. The volatile oil is found in a layer of very large cells in the testa.

The seeds have a powerful aromatic odour and an agreeable, pungent aromatic taste, but the pericarps possess neither aroma nor taste.

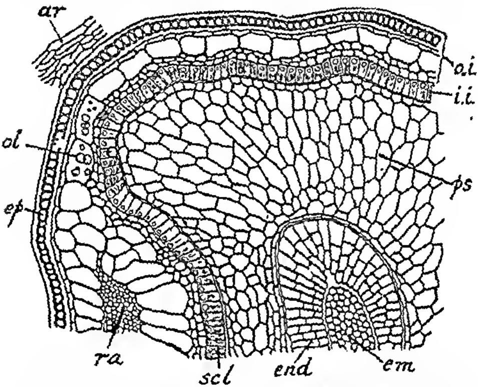


FIG. 89. *Elettaria Cardamomum* var. *minuscula*, seed, transverse section × 150. *ar*, arillus; *em*, embryo; *end*, endosperm; *ep*, epidermis; *i.i.*, inner integument, *o.i.*, outer integument; *ol*, oil globules; *ps*, perisperm; *ra*, raphe; *scl*, sclerenchyma. (After Tschirch and Oesterle.)

The seeds of fruits which have partially opened are less aromatic, and such fruits ("splits") are less esteemed.

The proportion by weight of pericarp to seeds of cardamom fruits is about 1 to 3.

Histology. The *pericarp* has an outer epidermis of small polygonal tabular cells and a mesocarp of thin-walled parenchyma in which are a few scattered cells with brown resinous contents; some of the cells contain calcium oxalate in small or almost needle-shaped prisms and often in radiating groups. The mesocarp is traversed longitudinally by vascular bundles, each of which is partially surrounded by a sheath of sclerenchymatous fibres, which are lignified. The vessels of the bundles are unlignified or the middle lamella only is lignified. The *seed* has externally an aril composed of a few layers of thin-walled elongated cells which contain small globules of oil. The epidermis of the testa consists of elongated fusiform cells, about 250 to 1000μ long, and nearly square in

section, being about 18μ wide and 25μ high. Beneath this is a single layer of small-celled flattened parenchyma and then a layer of large rectangular cells about 80 to 120μ long and 20 to 45μ wide and high and containing globules of volatile oil. Within the large-celled layer are two or three layers of small-celled parenchyma. These layers together form the outer seed-coat, which widens around the raphe where the vascular strand is surrounded by large oil-cells. The inner seed-coat consists of two layers only, the outer is a layer of beaker-shaped polygonal prisms each about 15 to 25μ in length and breadth and 30μ high; they are very heavily thickened, especially on the inner tangential surface, so that only a small lumen remains at the upper end, and this is nearly filled by a

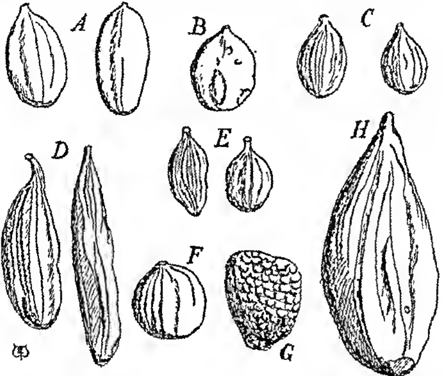


FIG. 90 Cardamom fruits. *A*, Mysore *B*, Mangalore. *C*, Malabar. *D*, long wild native (*E. cardamomum* var. *major*). *E*, Aleppi. *F*, cluster (*Amomum kepulaga*) *G*, seed of *F*. *H*, Korarima (*Aframomum korarima*). All fruits natural size; $G \times 4$.

nodule of silica, about 10 to 15μ in diameter. The inner layer of the inner seed-coat appears in transverse section as a narrow hyaline band. The perisperm consists of thin-walled parenchymatous cells, measuring about 40 to 100μ, each filled with a mass of starch grains which are rounded or polyhedral and about 3 to 5μ in diameter. In each starch mass there are embedded from one to several small prisms of calcium oxalate. The cells of the endosperm measure 20 to 40μ and contain a hyaline yellowish mass which stains deep yellow with iodine and red with Millon's reagent indicating a protein nature. The embryo consists of thin-walled cells.

Constituents. The principal constituent of the seeds is the volatile oil, of which they yield from 2 to 8 (average about 5) per cent. They also contain abundance of starch. Good ripe seeds yield about

Constituents. The principal aromatic constituent of vanilla pods is vanillin (about 2 per cent.), though probably other aromatic substances are present; it is contained in the fluid secreted by the inner epidermis of the pericarp, which gradually permeates the whole fruit. The green fruits (before curing) contain three glycosides, viz., glucovanillic alcohol, glucovanillin, and a third which yields with emulsin an ester with a strong, sweet odour. Glucovanillic alcohol yields by hydrolysis dextrose and vanillic alcohol which oxidises to vanillin; it appears to be the chief [illegible] obtained [illegible] It also [illegible] zoin, and other drugs; it is now prepared in large quantities from eugenol, the principal constituent of clove oil. Vanillin is also being made from waste sulphite liquors from the manufacture of wood pulp.

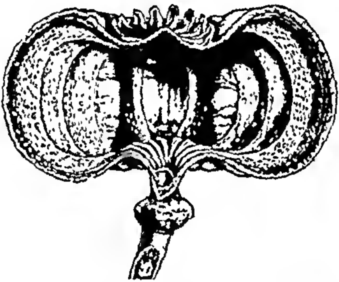


FIG. 91. Poppy capsule, cut vertically. (Planchon and Collin.)

FIG. 92. Poppy seed. Magnified (Bentley and Trimen.)

POPPY CAPSULES. Fructus Papaveris. Poppy Heads

Sources. Poppy heads are the dried, nearly ripe capsules of *Papaver somniferum* Linn., family Papaveraceæ, the opium poppy. The plant is probably a native of Asia Minor, but is now widely cultivated and is grown in England for the production of poppy heads and seeds.

Description. The *capsules* vary much in size and shape, being ovoid or globular or depressed at the apex and base. They are about 3 to 4 cm. in diameter, but the depressed ones are often as much as 8 cm. across. They are glabrous, pale yellowish brown and often marked with darker spots. At the base is a short piece of peduncle and the thalamus which appears as a slight swelling on the stalk and is marked with scars left by the fall of the perianth parts. At the apex is the persistent sessile radiate stigma with about eight to sixteen rays. The capsule is unilocular with eight to fifteen parietal placentæ which extend towards the centre of the loculus in the form of thin plates, to the surfaces of which the numerous small seeds are attached. The capsule dehisces by pores just beneath the stigma;

3·5 to 5·5 per cent. of ash, unripe seeds more; ripe fruits from 4 to 7 per cent.

Substitutes and Adulterants. *Long wild natives*: these are the fruits of *E. Cardamomum* var. *major* Thwaites, imported from Ceylon; they are distinguished by their elongated shape, being about 3 to 4 cm. long and 1 cm. wide, and often arcuate, shrivelled appearance, and greyish-brown colour; the seeds closely resemble the genuine drug, but have a slightly bitterish taste and a different odour. They are used for the production of a commercial cardamom oil, and also for making liqueurs and for flavouring.

Round or Cluster cardamoms (*Amomum Kepulaga* Sprague and Burkill); fruits globose, about 12 to 15 mm. in diameter; seeds have strong camphoraceous taste (Java); frequently found in imported shelled seeds.

Korarima cardamoms (*Aframomum Korarima* Pereira); fruits large, ovate, about 4 cm. long and 2 cm. wide, pointed; seeds larger than genuine, reddish-brown, striated; taste camphoraceous (Abyssinia).

Bengal cardamoms (*A. aromaticum* Roxburgh); fruits globose, with seven to thirteen narrow, membranous, longitudinal wings; seeds about 3 mm. long; taste very aromatic, camphoraceous (Nepal, India).

Wild Siamese cardamoms (*A. xanthioides* Wallich); fruits spiny; seeds resemble genuine, but have a somewhat terebinthinate taste. The seeds usually remain united in a three-lobed mass, twelve to eighteen seeds in each loculus.

Cardamom Husks. The pericarps of cardamoms are imported in compressed masses; the powdered husks are sometimes used to mix with cattle foods.

Uses. Cardamoms are employed as an aromatic carminative and as an agreeable flavouring agent.

VANILLA. Fructus Vanillæ.

Sources and History. Vanilla consists of the full-grown, unripe, cured fruits of *Vanilla planifolia* Andrews, family Orchidaceæ. The plant grows wild in the woods of the east coast of Mexico and, when the Spaniards conquered that country, they found vanilla in use by the Aztecs for flavouring chocolate. It was brought to Europe about 1510. The plant has been introduced into Réunion, the Seychelles, Mauritius, Tahiti and Java, in which places it is now cultivated.

Cultivation and Collection. *Vanilla planifolia* is a climbing orchid and the plants are called vines; they are raised from cuttings taken from any part of the plant and are trained on poles about 1·5 metres high and spaced about 2 metres apart. In Mexico the flowers are pollinated by particular insects, but in other habitats pollination is done by hand. Full crops are yielded from the fourth year onwards. The fruits are full grown in July to August and are collected when they begin to turn yellowish-brown. They are then subjected to a process of fermentation and slow drying which occupies several weeks, during which the fruits become nearly black and covered with minute crystals. They are sorted according to size and tied in bundles of twenty-five to fifty, packed closely in tin boxes, which are enclosed in wooden cases for export.

Description. The fruits are slender linear capsules about 15 to 25 cm. long and 8 to 10 mm. in diameter, flattened cylindrical, usually curved at the stalk end, nearly black with a longitudinally wrinkled surface covered with minute crystals of vanillin. The capsule is unilocular, with three carpels, and contains innumerable minute black seeds embedded in a dark aromatic balsamic fluid secreted by the short hair-like cells of the inner epidermis of the pericarp. The odour and taste are agreeably fragrant and aromatic.

there is one pore to each carpel. The pericarp is odourless, but has a bitter taste. The *seeds* are white to slate-grey—the darker coloured seeds are known as *maw seed*—sub-reniform and about 1 to 1·25 mm. long. The surface is covered with polygonal reticulations about nine in the length and five in the width of the seed; the hilum and micropyle are situated in the slight depression near the smaller end. The embryo is curved and is embedded in an abundant oily endosperm. They are inodorous and the taste is oily.

Constituents. Poppy capsules contain the principal constituents of opium. Ripe capsules have been found to contain from 0·018 to 0·28 per cent. of morphine, unripe from 0·056 to 0·66 per cent. Poppy capsules also contain meconic acid, an organic acid found only in the latex of the opium poppy. Although this acid is not an active constituent, the detection of its presence is often important as indicating a preparation of poppy capsules or of opium.

The seeds are free from morphine, but are said to contain traces of narcotine and amorphous alkaloid; the principal constituent is 50 to 55 per cent. of a pale yellow fixed oil; it is a drying oil and is used by artists as well as for culinary and various technical purposes.

Uses. The action of poppy capsules is the same as that of opium, but much weaker. The warm decoction is a favourite anodyne fomentation. The extract and syrup are uncertain remedies, and preparations of opium are in every respect preferable.

PRUNE. *Prunus*

Sources. Prunes are the dried ripe fruits of *Prunus domestica* Linn. var. *Juliana* DC, family Rosaceæ. They are imported chiefly from the south of France and from California.

Collection and Preparation. The prunes are gathered when ripe and are dried for a day or two in the sun; they are then heated in an oven for six hours on three successive days at temperatures of 45° to 60° C. for the first day, 65° to 70° C. on the second, and 80° to 90° C. on the third. After each baking the prunes are exposed to the air. The method described is that followed in France.

In California the fruits are spread on wicker trays and dried in a current of warm air below 100° C. for about twelve to fifteen hours; they are then cooled and are piled up in lofty chambers for ten to fourteen days, during which the moisture remaining in the fruits becomes evenly distributed.

Description. Prunes are ovoid-oblong drupes, about 3 to 4 cm. long and 2 to 3 cm. wide; the epicarp is purple-black, glaucous and shrivelled, it is marked below by a circular scar, about 3·5 mm. in diameter, where the stalk was attached, and at the apex is a small brown point, where the style has fallen away. The sarcocarp is yellowish-brown and succulent; the endocarp is flattened ovoid, about 2 to 2·5 cm. long, 1·5 cm. broad and 0·6 cm. thick, hard, woody and irregularly ridged, light brown in colour. The seed is solitary with a brown testa and a taste which is bitter and resembles that of benzaldehyde. When used as a drug the endocarp and seed are rejected. The drug has a faintly aromatic odour and a slightly acidulous, sweet and fruity taste.

Constituents. The pulpy tissue of the sarcocarp contains about 12 to 25 per cent. of sugar, also malic acid and salts of organic acids. The seed contains fixed oil, amygdalin and emulsin.

Uses. Prunes are both nutrient and gently laxative in action; they are used medicinally in combination with other laxatives.

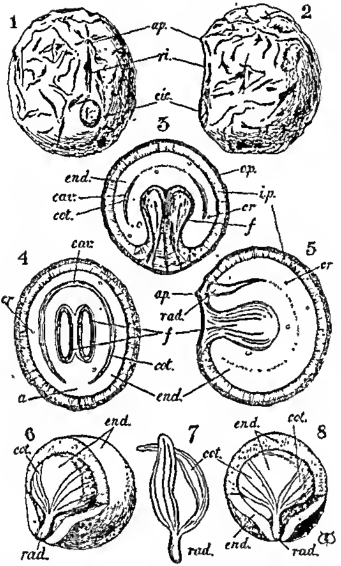


FIG. 93. Cocculus indicus. 1. Fruit, showing the ridge, ri., the apex, ap., and the stalk scar, cic. 2. Fruit seen from the side 3. Transverse section of the fruit. 4. Longitudinal section cut at right angles to the median plane. 5. Median longitudinal section. 6. Seed viewed partly from the side after removal of the upper distal part of the endosperm to the level of the cotyledons 7. An isolated embryo. 8. The same dissection as 6, viewed directly

All × 3 (Wallis.)

COCCULUS INDICUS. Fructus Cocculi. Levant Berries; Fishberries; Hock Enderbery

Sources, etc. Cocculus indicus consists of the dried ripe fruits of *Anamirta paniculata*, Colebrooke, family Menispermaceæ. The plant is a tall woody

climbing shrub growing in eastern India and in the Malay Archipelago; the drug is exported chiefly from Bombay and Madras.

The name Levant berries was given to them because in the sixteenth

[illegible]

Cock Anterbery and Hock Enderbery.

[illegible]

commerce are dark brown or nearly black and externally are much and irregularly wrinkled owing to the shrinkage of the succulent outer part of the pericarp; the inner part of the pericarp is hard and woody. Each fruit is about 11 to 12 mm. long and 9 to 10 mm. in transverse diameter. The fruit has a ventral ridge about 5 to 6 mm. long between the remains of the stigma and the scar left by the stalk; from this ridge the pericarp curves evenly in all directions to form a sub-reniform fruit. On the ventral side of the pericarp there are two narrow [illegible] well, which in longitudinal sections appe[illegible] The *seed* is cup-shaped and consists chiefly [illegible] in which is embedded an embryo consisting of a terete superior radicle—pointing towards the stigma—and two narrow foliaceous cotyledons each enclosed in a narrow longitudinal cavity in the endosperm. The fruits are odourless; the pericarp is tasteless and the seed is very bitter.

Constituents. The seed contains from 1 to 1·5 per cent. of an intensely bitter, crystalline principle, picrotoxin, accompanied by a crystalline but tasteless body, cocculin, and a large proportion of fat. Picrotoxin, $C_{45}H_{50}O_{19}$ (m.p. 199°), contains no nitrogen and is therefore not alkaloidal, nor does it possess glycosidal properties. It is readily separable into toxic picrotoxinin, $C_{15}H_{16}O_{6}$, and non-toxic picrotin, $C_{15}H_{18}O_{7}$, but its further constitution is as yet unknown.

From the pericarp, which is tasteless, two alkaloids, menispermine and paramenispermine (Pelletier and Couerbe, 1833), have been isolated, but they require re-investigation.

Uses. Cocculus indicus is now used almost exclusively for the preparation of picrotoxin, which is a powerful convulsive poison; it has been given internally to check the night-sweating of phthisis, and has also been employed to destroy pediculi. The power possessed by the fruits, when thrown into water, of stupefying fish has long been known, and is due to the picrotoxin contained in the seed. So susceptible are fish to the influence of picrotoxin, that they have been used as a means of detecting its presence. Some 300 other plants, belonging to a variety of families, however, have a similar action upon fish.

Picrotoxin is given intravenously to counteract the coma of barbiturate poisoning.

LAUREL BERRIES. Bay Berries, Fructus Lauri

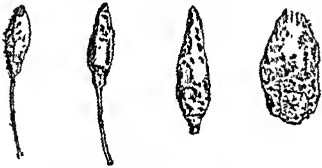
Sources. Laurel berries are the dried ripe fruits of the Bay Laurel, *Laurus nobilis* Linn., family Lauraceæ, a small tree indigenous to the south of Europe and often cultivated in gardens

Description. The dried fruits are drupaceous, ovoid, about 15 mm. long and 10 mm. wide. The outer surface is glabrous, shining, nearly black and is coarsely wrinkled owing to the shrinkage of the narrow succulent region beneath the epidermis. The remains of the style appears as a small point at the apex, and a small scar at the base marks the point of attachment of the fruit to the thalamus. The endocarp is thin and woody and

the *testa* is adherent to its inner surface; the entire pericarp is about 0·5 mm. thick. The kernel of the seed consists of two large plano-convex cotyledons and a small superior radicle; it lies loose within the united pericarp and testa; it is brownish-yellow, starchy and oleaginous, with an aromatic odour and aromatic and bitter taste. The pericarp is more bitter, but less aromatic than the kernel.

Constituents. Laurel berries contain about 1 per cent. of an aromatic volatile oil and 25 to 30 per cent. of fat. The latter, separated by hot pressure, is the *Oleum Lauri Expressum* of commerce; when pure it has a dull green colour, granular consistence, and aromatic odour. The principal constituent is trilaurin (glyceryl laurate), the odour being due to the volatile oil, and the green colour to chlorophyll. The volatile oil consists of cineol (eucalyptol) 50 per cent., accompanied by eugenol, pinene, geraniol etc.

Uses. The expressed oil is sometimes used in stimulating liniments and in veterinary practice.



A *B* *C* *D*

FIG. 94. *A*, Zanzibar. *B*, Sierra Leone. *C*, Japanese chillies. *D*, Bombay capsicums. Natural size. (*Chemist and Druggist.*)

CAPSICUM FRUITS. Fructus Capsici. Capsicum, Cayenne Pepper, Chillies

Sources. The capsicum fruit used medicinally in Great Britain is the fruit of *Capsicum minimum* Roxb., family Solanaceæ, fruits which are known commercially as "chillies." It is cultivated in many parts of the world such as southern India and South America, but more especially in Africa. The drug is exported chiefly from Zanzibar, Nyassaland and Sierra Leone.

Cultivation and Collection. *Capsicum minimum* is a perennial shrub, but is usually grown as an annual. Seed is sown at successive intervals so as to provide fruits throughout the year. The plants grow rapidly and yield fruit in about six months. The flowers are borne on erect pedicels and are succeeded by fruits which are gathered when just beginning to change colour and are dried in the sun.

Description. The fruit of *Capsicum minimum* Roxb. is a narrowly ovoid or ovoid-conical pod about 12 to 20 mm. long and 4 to 7 mm. wide; it is superior and sometimes the inferior calyx and the pedicel, which together are about 20 to 30 mm. long, remain attached. The calyx is about 4 mm. long, cup-shaped and has five inconspicuous teeth. The *pericarp* is glabrous, somewhat shrunken, thin, more or less

translucent and leathery and orange-red in colour; it is divided by a membranous longitudinal dissepiment into two loculi with axile placentation and from five to ten seeds in each loculus. The proportion by weight of pedicel and calyx in the entire fruit is about 12 per cent. The *seeds* are disc-shaped, about 3 to 4 mm. long, 2·5 to 3 mm. wide and 0·5 to 1·0 mm. thick; they are slightly pointed at the proximal end where the hilum and micropyle are situated. The testa is pale buff coloured; the kernel consists of an abundant oily endosperm in which a narrow, coiled embryo is embedded.

Capsicum fruits have a characteristic but not powerful odour, and an extremely fiery, pungent taste. The latter resides principally in the membranous dissepiment.

Varieties. *Sierra Leone*: these are regarded as the most pungent of all. The pod is rather slender, bright in colour, with the stalk only occasionally attached.

Nyassaland closely resemble Sierra Leone, but are rather brighter and more free from stalk.

Zanzibar are usually duller in colour, more stalky, and the pod rather shorter and broader. The calyx and pedicel are usually present in small amount, forming about 1·3 to 2·9 per cent. of the drug.

Histology. The *pericarp* consists of four distinct regions, viz., (1) The outer *epidermis* composed of sub-rectangular cells, often arranged in rows of five to seven, about 25 to 60μ long and wide and 15 to 20μ high, the outer walls are evenly thickened and are cuticularised. (2) The parenchyma of the mesocarp composed of rounded cells with cellulose walls, about 30 to 85μ long and 15 to 20μ wide and high; most of them contain yellowish oily droplets and yellowish-red chromatophores; an occasional cell is filled with sandy calcium oxalate; small vascular bundles occur towards the inner margin of this region. (3) A single layer of very large cells, about 0·8 to 1·7 mm. long, 0·2 to 0·4 mm. wide and 0·15 mm. high; these cells have cellulosic walls. (4) The inner epidermis, the endocarp,

island under each large cell. This type of endocarp is characteristic of the genus *Capsicum*. The *dissepiment*, about 0·2 mm. thick, is composed of thin-walled parenchyma. Each epidermis is developed as a secreting

polygonal-tabular cells about 15 to 20μ in

h and each cell with a prominent nucleus.

d in large bladdery patches, beneath which

is a secretion of oily droplets amongst which crystalline plates of capsaicin occasionally occur. The *seed* has a very characteristic outer epidermis of cells with wavy anticlinal walls and a heavy lignified thickening of the horse-shoe or beaker-shaped type. On the flat faces of the seed these cells are about 120 to 210μ by 20 to 160μ in surface view and *60μ high; on the*

glandular trichomes.

Constituents. The most important constituent of capsicum fruit is the pungent principle, capsaicin (0·05 to 0·07 per cent.), first isolated by Thresh (1876) in colourless, odourless crystals. It also contains a

minute quantity of a liquid alkaloid which is not pungent, a fixed oil, carotin, and a red colouring matter, capsanthin; the seeds may contain traces of starch.

Capsicum fruits yield about 5 (not over 7) per cent. of ash and from 20 to 25 per cent. of alcoholic extract, known in commerce as capsicin; the same name has also been applied to an ethereal extract as well as

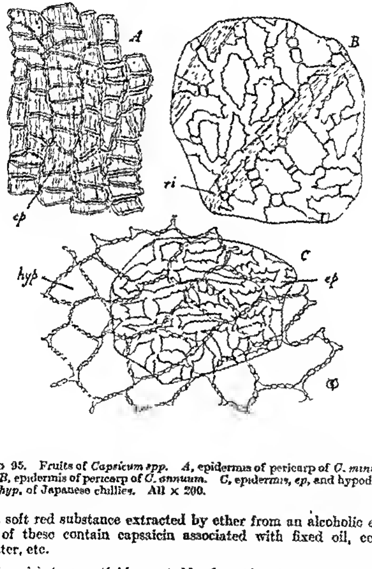


FIG 95. Fruits of *Capsicum spp.* *A*, epidermis of pericarp of *C. minimum*. *B*, epidermis of pericarp of *C. annuum*. *C*, epidermis, *ep*, and hypodermis, *hyp*, of Japanese chillies. All × 200.

to a soft red substance extracted by ether from an alcoholic extract. All of these contain capsaicin associated with fixed oil, colouring matter, etc.

Capsaicin (capsacutin) is secreted by the epidermis of the dissepiments of the fruit, between the outer cell wall and the cuticle. Capsaicin, $C_{18}H_{27}NO_3$, melts at 65° and at higher temperatures is volatile, the vapour being extremely irritating; it is a vanillyl amide, the dihydro derivative of which has been synthesised (E. K. Nelson and L. E. Dawson, 1923). The

pungency is not affected by 2 per cent. alcoholic caustic potash, but is destroyed by oxidation with potassium bichromate or permanganate.

Uses. Cayenne pepper is applied externally as a stimulant and counter-irritant; internally it is used as a pungent stomachic carminative and stimulant, to dispel flatulence and rouse the appetite.

Substitutes and Adulterants. *Japanese Chillies*: these are distinguished by their very bright, crimson red colour and freedom from stalk; the cells of the epidermis of the pericarp have a *smooth* (not striated) *cuticle, strongly thickened walls and radiate lumen*; the cells of the single-layered hypodermis have rather thick, pitted, *cuticularised* walls. These fruits are slightly larger than African chillies, being about 15 to 26 mm. long and 5 to

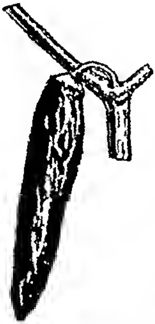


Fig. 96. *Capsicum annuum*, fruit. Natural size. (Bentley and Trimen.)

Fig. 97. Natal capsicum fruit. Natural size. (*Chemist and Druggist.*)

9 mm. wide and are less pungent than the African, but are valued for their very bright colour. The small Japanese chillies of commerce are derived from a species of *Capsicum* which has not yet been fully described or named.

Bombay capsicums, the fruits of *C. annuum* Linn., are nearly globular, ovoid or oblong; they are larger than the fruits of *C. minimum*, being about 5 to 12 cm. long and 2 to 4 cm. wide, and have a less pungent taste. The stalk is usually bent, the calyx larger, the pericarp more leathery, and the dissepiment does not extend throughout the entire length of the fruit. The colour of the pericarp may be red, yellowish-red or brownish-red. The cells of the epidermis are *polygonal*, larger than those of *C. minimum* and with numerous pits, while the hypodermis *consists of several layers of cuticularised collenchymatous cells.*

Natal capsicums, average about 8 cm. in length and have a beautiful, transparent, red pericarp.

Paprika, which is largely grown and used in Hungary, is derived from *C. tetragonum* Miller, or from *C. annuum* Linn. var. *longum*; the fruits are large and usually more or less tetragonal in shape; by cultivation the pungency is diminished, but the colour, odour and flavour increased.

Bird Pepper, the powder of which is given to canaries to improve the colour of their plumage, is derived from *C. annuum* var. *grossum*, Sendtn. (Spanish) or *C. annuum* Linn. var. *longum* (Hungarian); it is free from pungency.

PIMENTO. Fructus Pimentæ. Allspice; Jamaica Pepper

Sources, etc. Pimento consists of the dri[illegible] fruits of *Pimenta officinalis* Lindley, [illegible] The panicles of berrie[illegible] in the sun; the drying occup[illegible] the colour of the fruits changes to reddish[illegible] stalks are removed and the fruits packed for export. The fruits are collected while green because the aroma disappears during ripening.

Description. The berries are subspherical, 5 to 8 mm. in diameter, reddish-brown, surmounted by the remains of the four-sepalous calyx. The surface is rough from the presence of ovoid oil-glands embedded in the tissues of the thin pericarp. The fruit has two loculi and one exalbuminous seed in each; the seeds contain oil-glands, but are less aromatic than the pericarp. The odour is agreeably aromatic and the taste warm and aromatic and is supposed to resemble that of a mixture of cinnamon, nutmegs and clove, hence the name "allspice."

Constituents. Pimento contains tannin and 3 to 4·5 per cent. of volatile oil, which consists chiefly of eugenol, about 65 per cent.

Uses. Pimento is used as a flavouring agent and as an aromatic stimulant, resembling cloves in its action.

BITTER APPLE. Fructus Colocynthidis. Colocynth, Colocynthis

Sources. Colocynth or bitter apple consists of the pithy pulp removed from the ripe or nearly ripe fruits of *Citrullus colocynthis* Schrader, family Cucurbitaceæ. The plant is a herbaceous perennial with a prostrate stem with tendrils, much like a vegetable marrow; it is cultivated and the drug is collected in Cyprus, Syria, Spain, Egypt and Morocco.

Collection and Preparation. The fruits are gathered in the autumn when they are ripe and yellow; they are dried in the sun and then freed from the rind or epicarp by peeling with a sharp, pointed knife. Fruits are sometimes peeled before drying, but they keep a better shape if peeled after drying

Description. The peeled fruit is 5 to 8 cm. in diameter, sub-spherical, nearly white and very light in density. Externally it is marked by spiral flattish areas, each about 1 cm. wide, due to the use of a knife for peeling the fruit. If cut transversely, three large splits are seen radiating from the centre and dividing the fruit into three parts; each part contains two groups of seeds near the periphery, the whole remaining space being filled with a pithy parenchyma. In each fruit there are 200 to 300 seeds, which constitute about three-quarters of the weight of the peeled fruit.

The pulp, freed from the seeds, occurs in irregular broken pieces each

usually showing small ovoid impressions of the seeds and a portion of the outer surface of the peeled fruit with its knife marks.

The three splits arise in the tissue of the three placentas; the ovary is at first three-celled with axile placentation, the three placentas grow out from the centre towards the circumference where each divides into two, each half curving backwards and carrying a group of seeds with it. It is along the middle line of each outgrowth from the centre that a split eventually occurs.

Colocynth is odourless, but has an intensely bitter taste.

Owing to the difficulty of completely removing the rind or epicarp and the seeds, one always finds a small amount of each in the commercial article, which should contain not more than 2 per cent. of epicarp or 5 per cent. of seeds. The *epicarp* has a granular buff-coloured, glabrous outer surface and a smooth paler inner surface, sometimes marked by impressions of the seeds; it is about 1 mm. thick. The *seeds* are flattened ovoid, about 6 to 8 mm. long, 4 to 5 mm. wide

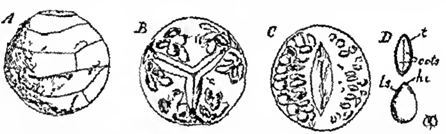


FIG. 98 *Citrullus colocynthis*, fruit. *A*, peeled fruit, showing knife-marks. *B*, transversely cut fruit, showing six groups of seeds and three large splits in the placentæ. *C*, longitudinally cut fruit. *D*, seed, external surface and longitudinal section; *cots*, cotyledons; *hi*, hilum; *l.s.*, linear split; *t*. testa. *A*, *B* and *C*, about half natural size; *D* × 1·5.

and 2 mm. thick The testa is yellowish-white in unripe seeds to nearly black in ripe ones; on each face near the pointed end there are two small linear splits, about 2 mm. long; the embryo is large, straight and oily.

Histology. The *pulp*, *i.e.*, the mesocarp and placentas, consists of a large-celled parenchyma, the cells attaining a diameter of 300µ and being separated by intercellular spaces; where the cells are in contact there are flat, rounded, finely pitted areas about 30 to 100µ in diameter. The walls are partly lignified, sometimes largely cellulosic. Narrow vascular strands occur here and there. The *rind* or epicarp has an epidermis of polygonal prismatic cells about 20 to 25µ high and 15µ in diameter, the outer and radial walls are thickened and cuticularised except for the layer next the lumen; large stomata occur at intervals. Beneath the epidermis is a layer of about fifteen rows of thin-walled parenchyma and immediately within this a layer of thick-walled lignified sclerenchyma. The outer one to three layers of sclereids are heavily thickened, but the inner layers are larger and have thinner walls, gradually merging into the parenchyma of the pithy pulp. The *seed* has a palisade epidermis of polygonal prismatic cells about 60µ high and 20µ in diameter. The anticlinal walls have about ten to twelve vertical tapering bars of thickening which, when focussed in surface view, give the walls a characteristic beaded appearance. The contents of the epidermal cells are brown and react for tannin. The remainder of the testa consists of a heavily thickened sclerenchyma about

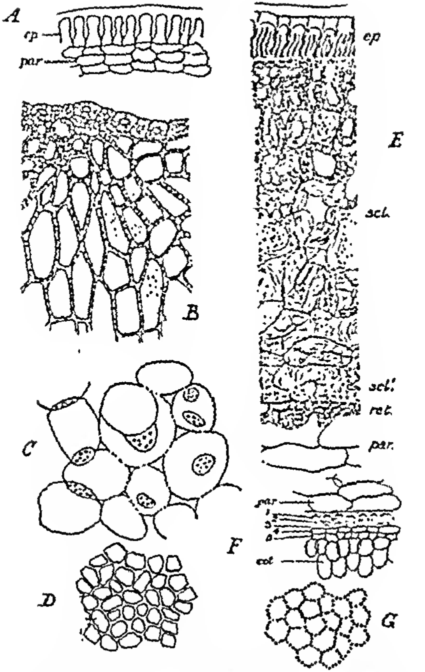


FIG 99 *Citrullus colocynthis*, fruit and seed. *A*, epidermis, *ep*, and parenchyma, *par*, of the pericarp *B*, sclerenchyma of outer part of pericarp. *C*, pithy part of pericarp *D*, epidermis of pericarp in surface view *E*, transverse section of part of the testa of the seed; *ep*, epidermis; *scl*, sclerenchymatous tissue; *scl'*, innermost layer of the same; *ret*, reticulated cells, *par*, parenchyma *F*, innermost part of testa and part of cotyledon, *cot*, cotyledon; *par*, parenchyma abutting on the reticulated cells, 1, 2 and 3, collapsed layers; 4, inner epidermis of remains of endosperm, 5, epidermis of cotyledon. *G*, epidermis of testa in surface view. All except *C* × 240. *C* × 60. (After Greenish.)

eight to ten cells wide, within which is a narrow layer of thin-walled more or less collapsed parenchyma four to five cells wide. The two inner layers of the sclerenchyma differ markedly from the outer cells, the innermost has lignified reticulate thickening and the cells often have dome-shaped projections towards the interior of the seed; the layer above this is very regular and the cells have stellate projections laterally. The embryo consists of thin-walled cellulose parenchyma containing fixed oil and small aleurone grains.

Constituents. The chief constituents of colocynth pulp appear to be an alkaloid producing very drastic purgation even in small doses, and amorphous resins soluble in ether and chloroform which also are powerful purgatives. Other constituents are a crystalline alcohol, citrullol, and *a*-elaterin; neither of these is purgative; *a*-elaterin is also present in elaterium (see "Elaterium"). The presence of a crystalline glucoside, colocynthin, formerly reported, has not been confirmed. The pulp also contains from 1·0 to 1·3 per cent. of fixed oil and yields from 7 to 13 per cent. of ash; it contains no starch. The seeds contain 15 to 17 per cent. of fixed oil and have an ash of 2·5 to 3 per cent.

Varieties. *Turkey colocynth*, imported from Syria, Cyprus, etc.; the fruits are carefully peeled, nearly white, and contain a large proportion of pulp.

Egyptian colocynth, from the Anglo-Egyptian Sudan, very similar to Turkey colocynth, but in fragments freed from the seeds.

Spanish colocynth is less sightly, often discoloured, and contains less pulp.

Mogadore colocynth is occasionally imported; it is unpeeled.

Uses. Colocynth is a gastro-intestinal stimulant or irritant and one of the most powerful of the official purgatives acting as a hydragogue cathartic. It is employed as an occasional purgative to produce free evacuation of the bowels in bilious derangements of chronic constipation, but as it causes griping is seldom prescribed alone.

BAEL FRUIT. Fructus Belæ. Indian Bael; Bengal Quince

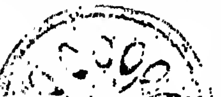


FIG. 100.—Bael fruit. Transverse section of a small specimen. Natural size. (Holmes.)

Sources, etc. Indian bael is the fruit of *Ægle Marmelos* Correa, family Rutaceæ, a tree attaining a height of 12 metres and growing both wild and cultivated throughout the entire Indian peninsula. Being a sacred tree, the Hindus plant it near their temples. It became known to the Portuguese as a remedy for dysentery when they occupied the eastern shores of India, the pulp of the half-ripe fruit being eaten while fresh. It was introduced into European medicine about 1850.

Description. The fruit is subspherical, about 5 to 10 cm. in diameter. The epicarp is a hard woody rind about 1·5 to 2 mm. thick, externally smooth or slightly

granular and reddish-brown in colour, with a circular scar left by the removal of the stalk. The fruit consists of ten to fifteen carpels, each containing several hairy seeds embedded in a reddish pulp, which is aromatic and mucilaginous when fresh, but hard when dry. The fruit is sometimes imported fresh, but usually in dried quarters or transverse slices.

Constituents. As far as is known, the principal constituent of bael fruit is mucilage. Traces of tannin are present in the ripe, but not in the unripe, fruit.

Substitutes. Several substitutes for bael have been met with, viz.:

Mangosteen fruits (*Garcinia Mangostāna* Linn., family Guttiferæ); these may be distinguished by the darker rind, to which the pulp does not firmly adhere, and by the wedge-shaped, radiate stigmas; they contain crystalline mangostine, tannin, and resin.

Wood apple (*Feronia elephantum* Correa, family Rutaceæ). The fruit is five-lobed but one-celled, and has a rough exterior.

Pomegranate rind may be distinguished by its astringent taste and the triangular impressions of the seeds.

Uses. In the fresh state Indian bael is a pleasant, refreshing fruit valuable in the treatment of diarrhœa and dysentery. A liquid extract from the *fresh* fruit appears to possess its specific action.

BITTER ORANGE. Fructus Aurantii. Seville Orange

Sources. The bitter or Seville orange is the fruit of *Citrus Aurantium Linn.* (*C. Aurantium* var. *Bigaradia*, Hooker filius; *C. vulgaris* Risso), family Rutaceæ, a small tree probably a native of north-eastern India, but cultivated in most warm countries. In Europe it is grown in the countries bordering on the Mediterranean. Bitter oranges are shipped chiefly from southern Spain (Seville and Malaga) and from Sicily (Messina and Palermo), Seville oranges being considered to be the best for medicinal use.

In addition to the fresh fruit the dried peel is also largely imported from Malta, Spain, and Morocco.

Cultivation and Collection. Seedlings are planted out when six to twelve months old, so that the trees are about 8 metres apart in the plantations, which are known as orange groves. They come into bearing when five to seven years old The yield of fruit is improved by manuring, weeding and working the ground between the trees. The fruit is collected while still unripe, packed in boxes and exported, the ripening being completed during transport.

Description. The fruit is sub-spherical, about 6 to 10 cm. in diameter, and is superior with a small point-like scar at the apex where the style was attached and a dry, disc-shaped remains of the nectary at the base. It is composed of eight to twelve carpels with the same number of loculi, each of which has two rows of seeds with axile placentation. Each loculus is completely filled by a pulp which originates as hair-like outgrowths from the inner epidermis of the outer pericarp wall and from the placenta. The pulp is sour and bitter. This type of berry is termed a *hesperidium*.

Fresh orange peel is cut from the orange when required for use It consists of the outermost part of the pericarp with as little as possible of the white pithy part or "zest" which latter is devoid of volatile oil and is lacking in bitterness In cutting the peel care is taken to prevent

rupture of the large ovoid oil-glands embedded in the orange-yellow outer part. The oil-glands give rise to numerous small projections on the outer surface of the fresh peel.

Dried orange peel prepared in England is in long spiral strips about 6 to 12 mm. wide and 2 to 3 mm. thick, cut by hand. Maltese peel is usually in narrow machine-cut strips, described as "fine cut" or "gelatin cut." The "fine-cut" peel is less esteemed because of the loss of aroma by excessive rupture of oil-glands during preparation. The dried peel is hard and brittle when dry; tough and supple when exposed to a moist atmosphere. The outer surface is rough, dark orange-red and shows numerous small circular depressions or pits above the oil-glands; the inner surface is whitish and pithy. The transverse section assumes a dark green colour when moistened with strong hydrochloric acid, a reaction that is occasionally useful in identifying the peel.

Constituents. Bitter orange peel contains volatile oil, aurantiamarin (an amorphous bitter principle), hesperidin, isohesperidin, hesperic acid (colourless, tasteless crystals), a bitter resin and bitter aurantiamaric acid. The peel yields from 3·5 to 6·5 per cent. of ash.

The seeds contain about 40 per cent. of fixed oil, pectin and a crystalline bitter principle, limonin.

Hesperidin, $C_{22}H_{26}O_{12}$, is a colourless, tasteless, crystalline glycoside that occurs in all species of *Citrus*; by hydrolysis it yields hesperetin together with dextrose and rhamnose; hesperetin may be split up into isoferulic acid and phloroglucin. It is not identical with the diosmin of buchu leaves. Hesperidin appears to be identical with or closely related to vitamin P.

Uses. Bitter orange peel possesses both aromatic and bitter properties, and is used as a tonic and as an agreeable flavouring agent.

Substitutes. The peel of the sweet orange is said to be frequently mixed with that of the bitter orange; it may be distinguished by being thinner, paler, and more yellow in colour and much less bitter in taste. Lemon peel (dried) scarcely changes colour with strong hydrochloric acid. *Dried orange peel* in curved pieces or "*quarters*," about 3 to 6 cm. long and 3 to 4 cm. wide at the middle, with acute ends, is usually green or greenish-brown in colour and is a regular article of commerce; it gives a good yield of volatile oil. *Indian orange peel* is also obtained from *Citrus Aurantium* grown in India; it is usually in irregular pieces of a rather dark colour.

Other Products of the Orange Tree

Oil of Neroli is the volatile oil distilled from fresh orange flowers; chief constituents linalol, geraniol (and their esters), limonene and methyl anthranilate (ortho-amidobenzoate).

Orange Flower Water is a saturated aqueous solution of the volatile oil of the flowers obtained during the distillation; the residue contains the bitter principle limonin (naringin).

Oil of Orange is the volatile oil obtained from the rind of the bitter orange; chief constituents d-limonene, citral, citronellal, decyl alcohol, methyl anthranilate.

Oil of Portugal, the volatile oil from the rind of the sweet orange, has similar constituents.

Oil of Petit Grain, the volatile oil obtained originally from the immature fruits but now from the leaves and twigs, has also a very similar composition.

LEMON. *Fructus Limonis*

Source, etc. The lemon is the fruit of *Citrus Limonia* Osbeck, family Rutaceæ, a small tree which, like the orange, is probably a native of northern India. It is cultivated in all countries bordering on the Mediterranean, especially in Sicily and southern Italy, in Spain and Portugal, and in the Riviera.

Cultivation and Collection. Orange seedlings are raised from seed and when about nine months old are planted out 1 metre apart; about six months later they are grafted with lemon and after about another twelve months are planted out 8 metres apart. They begin to yield fruit when five to seven years old.

The fruits are gathered whilst they are still green; the finest are wrapped in paper and exported in cases of 200 (Murcia lemons) to 360 (Messina lemons); less sightly fruits are packed in barrels and preserved with salt water. The finest lemons are those imported from Sicily (Messina and Palermo); those from Murcia are also of high quality, while Naples and Malaga lemons are less esteemed.

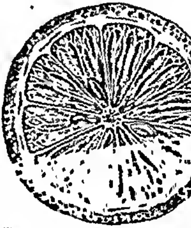


FIG. 101. Lemon. Transverse section. (Planchon and Collin.)

Description. The lemon is ovoid or obovoid, externally pale yellow and nearly smooth, about 6 to 10 cm. long and 4 to 7 cm. wide, with a nipple-shaped apex and a dry disc-like nectary at the base. It consists of about eight to ten carpels and has a similar number of loculi filled with pulp as in the orange. The pulp has an agreeable and strongly acidulous taste.

Fresh lemon peel is cut from the fruit when required for use; it consists of the outer yellow part of the pericarp with as little as possible of the white pithy zest. Externally it is yellow and smooth with numerous small elevations over the large oil-glands embedded in the hypodermal tissue It has a fragrant odour and a somewhat bitter taste.

Dried lemon peel occurs in long, usually spiral, strips about 6 to 15 mm wide, 2 to 3 mm. thick and up to 20 cm. or more long, some pieces with the nipple-shaped apex attached. The outer surface is yellow to yellowish-brown and is rugose and marked by numerous minute pits corresponding to the position of the subjacent oil-glands; the inner surface is whitish and somewhat lacunous. When dry it is brittle, but is tough and supple when moist.

Lemon Juice. Fresh lemons yield about 30 per cent. of juice, which, for pharmaceutical use, should be pressed from the fresh fruit. It is a turbid yellowish liquid with a characteristic odour and acid taste.

Large quantities of lemon juice are pressed in Sicily from the pulp that is left in the production of the volatile oil, the residual cake being used as cattle food. The juice is concentrated to a specific gravity of 1·233 to 1·235 and exported, chiefly to England, for the manufacture of citric acid; or the citric acid is precipitated as calcium citrate from which the citric acid is subsequently regenerated.

Constituents. The *peel* contains volatile oil, hesperidin, and vitamin B. The *juice* contains 6·5 to 8·5 per cent. of citric acid and also vitamin C. The amount of citric acid in the juice is largest in lemons imported in December and January, and smallest in August, both the fruit and the juice itself gradually diminishing in acidity when kept; [illegible]

Decitrated lemon juice is used for the manufacture of vitamin C concentrates, as also is orange juice.

Oil of Lemon. Volatile oil of lemon is prepared by two hand-processes based upon different principles and, though these processes are still used to a limited extent, the bulk of oil of lemon is now obtained by machines which are based upon the principles of the hand-processes.

Sponge Process. The lemons are cut into two pieces, either longitudinally or transversely; the pulp is removed from the halves by a [illegible] steeped in water for some hours. [illegible] holding one in the right hand and [illegible] oil-glands are ruptured and the ejected oil is absorbed by a sponge held in the left hand of the operator. When the sponge is fully charged it is squeezed or pressed and the liquid that accumulates is allowed to stand until it separates into an aqueous and an oily layer, which latter is decanted. After filtration the oil is put into copper cans for export. This process is very prodigal of time and labour, although it produces an oil of high quality. From about 350 to 500 gm. of oil are thus obtained from 1,000 lemons. Machines are now made to treat the lemon peels in an analogous way and will produce about ten times the amount of oil in one-third of the time; these machine-made oils are of high quality.

Ecuelle Process. In this process, used in the south of France, a shallow bowl-shaped pewter basin, called an ecuelle, is used to remove the oil. The basin is about 25 cm. in diameter and is studded inside with a large number of brass pins, about 1·25 cm. long, having somewhat blunt points. The fruits are rolled over these points with a moderate amount of pressure until the whole surface has been scarified and the liberated oil flows down into the hollow interior of the cylindrical handle, about 2·5 cm. in diameter and 12 cm. long, which is attached to the centre of the bowl. The contents are emptied into a larger vessel and are allowed to separate and the oil is decanted and filtered. Machines, which liberate the oil on the principle of the ecuelle process, are also made and produce an oil of satisfactory quality.

Oil of lemon is a pale yellow liquid of sp. gr. 0·857 to 0·861 and optical rotation + 57 degrees to + 65 degrees, consisting of about 90 per cent. of the terpene limonene and about 4 to 6 per cent. of the

aldehyde citral, which is the chief odorous constituent of the oil, Other odorous constituents are small proportions of citronellal, geranyl acetate, linalyl acetate, octyl and nonyl aldehydes.

Other Citrus Fruits

Bergamot. The fruit of *Citrus Bergamia* Risso, cultivated in southern Italy and Sicily. The volatile oil is obtained by rotating the fruits in a machine against sharp copper points, collecting and filtering the mixture of volatile oil and cell sap and decanting. The pulp is pressed and the

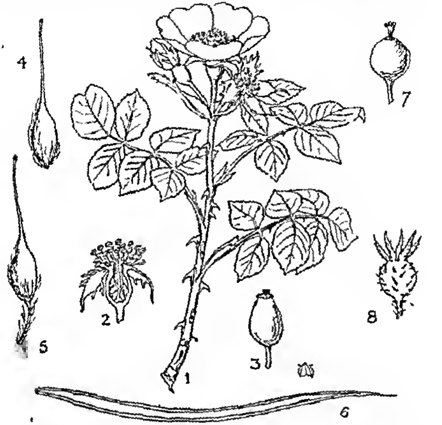


FIG. 102 *Rosa canina* 1, flowering twig, 2, vertical section of flower, after fall of petals; 3, fruit or hip; 4 and 5, achenes from interior of a hip, showing numerous hairs, × 3, 6, a single trichome × 60; 7, fruit of *R. arvensis*, the field rose, 8, fruit of *R mollis*, the downy rose

juice used for the production of calcium citrate or citric acid. The oil contains linalyl acetate (34 to 40 per cent), *d*-limonene and bergaptene.

Lime The fruit of *Citrus Medica* var. *acida* Brandis (West Indian Lime), or of *Citrus Limetta* Risso (Italian Lime). The volatile oil of the former has an odour of citronella and contains citral and limonene; that of the latter an odour of bergamot and has a composition similar to bergamot oil, but contains less linalyl acetate (26 per cent.). The pulp of both contains citric acid (about 7 per cent.).

HIPS. Rosæ Caninæ Fructus

Sources, etc. Hips are the fresh ripe fruits of *Rosa canina* Linn., the dog rose and of other species of *Rosa*, the principal of which are *R. arvensis*

Huds., the field rose, and *R. mollis* Sm., the downy rose. The fruits are collected from plants growing wild in Britain.

Description. The fruit of *Rosa* is an aggregate fruit formed from the apocarpous gynœcium of a single flower, it is an eterio of achenes, termed a cynarrhodon. That of *R. canina* is urn-shaped and about 2 cm. long, bright red and glossy externally and bears at its summit the scars left by the fall of five sepals. The bulk of the fruit consists of the succulent hollow thalamus which bears numerous achenes on its inner surface. The achenes themselves are hairy as also is the inner epidermis of the thalamus. The

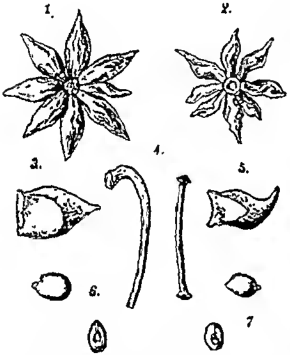


FIG. 103. Fruits of *Illicium verum* and *I. religiosum*. 1, entire fruit of *I. verum*; 3, a single carpel; 4, stalk (left); 6, seed; 2, entire fruit of *I. religiosum*; 4, stalk (right); 5, single carpel; 7, seed. (Vogl)

but the styles protrude in a distinct column. The fruit of *R. mollis* has five persistent sepals and the surface of the fruit is bristly. The taste is sweet, acidulous and slightly astringent.

The part used in making the confection is the pulp only and this is separated by rubbing the ripe fruits through a hair sieve.

In making the syrup, the fruits are first simmered with sufficient water to just cover them, after which they are mashed with a wooden spoon, transferred to a jelly-bag and the juice squeezed out. In this way, the skins, achenes and trichomes are all removed. The trichomes are 1·0 to 1·6 mm. long, unicellular, slenderly conical with a sharply pointed apex and walls which are 8 to 10μ thick. They are extremely irritating to the mucous membrane of the bowel and must be carefully removed in making the syrup (see Fig. 102).

Constituents. The pulp contains 11 to 15 per cent. of invert sugar, about 3 per cent. of citric and malic acids and about 2 per cent. of tannin; the red colour is due to carotin. There are also present vitamins C and P.

Uses. Hips are used in the form of a confection as a dietetic and as an excipient for pills. A syrup prepared from hips contains from 0·175 to 0·200 per cent. of ascorbic acid (vitamin C).

STAR ANISE FRUIT. *Fructus Anisi Stellati*

Sources. Star anise fruit is the ripe fruit of *Illicium verum* Hooker [illegible] -digenous to the southern and [illegible] mall proportion of the harvest [illegible] the distillation of the volatile oil.

Description. The fruit is an eterio of one-seeded follicles, normally eight in number. Each follicle is about 1·5 or up to 1·7 cm. long, up to 1·4 cm. deep and 4 to 5 mm. thick. The follicles are adherent by their bases to a central axis and radiate horizontally with the split ventral suture uppermost, disclosing the single reddish-brown, shining, hard seed. The carpels are reddish-brown, woody and somewhat wrinkled externally, paler smooth and glossy internally; they are boat-shaped and bluntly beaked at the apex. The pedicel is strongly curved at the distal end.

Both the pericarp and the kernel have an agreeable, aromatic odour and a sweet spicy taste.

Constituents. The chief constituent of the fruit is the volatile oil contained in the pericarp (about 10 per cent.) and in the kernel (about 2·5 per cent.) The oil closely resembles that of *Pimpinella Anisum* Linn. and may be substituted for it; it contains about 80 to 90 per cent. of anethol.

Uses. The oil is employed as a carminative and as a flavouring agent, especially in cough mixtures, as it is thought to possess a special action on the bronchial mucous surfaces.

Adulterant. Japanese star anise, also called sikimi fruits or bastard star anise (*Illicium religiosum* Siebold). These fruits find their way to the Indian and occasionally to the London market. As they are toxic they must be carefully distinguished from the Chinese. They are less regularly developed, and slightly smaller, up to 1·3 cm. long, 9 mm. deep and 5 mm. thick; the carpels are usually more wrinkled, the beak more acute and commonly directed upwards; the peduncle, to which the carpels seldom remain attached, is straight. The Japanese fruits have a balsamic, not anise-like odour, and a disagreeable, bitterish taste; the taste and odour are the best characters by which to distinguish the genuine from the false, as they can be applied to fragments of the fruit. Poisoning by bastard anise is of frequent occurrence in the Orient.

The toxic constituents of Japanese star anise are sikimitoxin (amorphous) and sikimin (crystalline); the drug also contains fixed oil, sikimic acid and sikimipicrin.

HOPS. Lupulus, Humulus, Strobili Lupuli

Sources. The hop, *Humulus Lupulus* Linn., family Moraceæ, is a diœcious scabrous climbing plant, with perennial root, widely diffused over Europe and England, growing in hedges and thickets. It is cultivated in England, Germany, Russia, California, etc.

Cultivation and Collection. Hops are grown from cuttings reared in a nursery and planted out 2 metres apart in the field. Poles 2·5 to 3·5 metres high are put in at the end of the first year and the soil is well manured; they yield fruit in the second year. The fruits are picked from the plant when fully developed, and dried; they are frequently exposed to fumes of burning sulphur (sulphur dioxide), by which the colour is preserved and change in the aroma is said to be hindered. They are sometimes packed loose, but usually they are pressed into compact bales known as "pockets."

Description. The hop is a compound or collective fruit formed from an entire female inflorescence. The inflorescence has a zigzag axis which bears a two-flowered cyme at each node. Each small cyme has two stipules with four bracteoles, often termed bracts, in the axil of each of which is a pistillate flower, which develops into a small fruit. The stipules and bracteoles become enlarged as the fruits develop and form the bulk of the strobile or hop fruit, usually termed a strobile, which is about 3 to 4 cm. long. In the strobile the stipules are flat, ovate and symmetrical, the

bracteoles are folded along one margin with a small fruit at the base of the fold and are ovate and markedly unsymmetrical. The stipules are about 10 by 5 mm to 20 by 10 mm. and the bracteoles are 15 by 7 mm. to 30 by 10 mm. The zigzag axis or "strig" is about 3 to 4 cm. long. Each small fruit is an achene with a dark violet pericarp, closely invested by an orange perigone; both the perigone and the basal part of each bracteole are covered by glistening yellow glands containing volatile oil. These glands when separated constitute the drug lupulin, which gradually turns brown during storage (see Lupulin, p. 22).

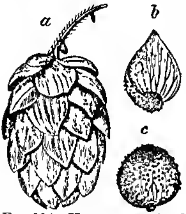


FIG. 104. Hop. a, strobile of the Hop, natural size. b, bract enfolding at its base a small fruit, and showing lupulin glands; natural size. c, fruit magnified, showing lupulin glands. (Tschirch.)

Constituents. Hops contain volatile oil, tannin, sugar, fatty acids, resins, etc.

The volatile oil (0·3 to 1·0 per cent.) consists chiefly of the terpene humulene.

The bitterness is due to a number of substances, only one of which, humulol, has been obtained crystalline and pure. Xanthohumol is an orange-yellow crystalline body. One of the constituent resins yields by oxidation valerianic acid, a reaction that explains the change in the odour when hops are kept.

Uses. The volatile oil produces sedative and soporific effects, whilst the bitter substances are stomachic and tonic; hops accordingly improve the appetite and promote sleep.

FIGS. Ficus; Caricæ

Sources. The fig is the dried ripe fruit of *Ficus Carica* Linn., family Moraceæ. It is cultivated in the Mediterranean regions and in California. The fruits are gathered when ripe and are dried in the sun.

Description. The fruit, known as a syconus, is developed from an entire inflorescence, the fleshy part being a hollow receptacle—the inflorescence axis—to the interior of which very numerous small flowers are attached. The fruits from these flowers are drupes, the stones of which are the minute "seeds" present in figs. The fresh fruit is pear-shaped, but the commercial dried fruits are irregular, about 5 cm. in length and breadth and 1 to 2 cm. thick. At one point on the surface may be seen the orifice of the receptacle surrounded by small bracts and at another part the short remains of the stalk is usually present. When young the receptacle contains laticiferous vessels filled with a milky latex; as it ripens the latex disappears, the fleshy wall fills with sugar and becomes edible. "Pulled" figs have been made supple by kneading. "Pressed" or "layed" figs have been flattened by packing into boxes. "Natural" figs have not undergone any such treatment. The chief varieties are, Elémé, exported from Smyrna, which are considered the best; Spanish from Malaga and Valencia; and Greek; the latter have thicker skins and are usually threaded on strings or packed in barrels.

Constituents. The chief known constituent is about 50 per cent. of invert sugar with some sucrose.

Uses. Figs are used as a dietetic and as a mild laxative.

CHAPTER XII

ENTIRE ORGANISMS

MANY entire organisms, both plants and animals, are used as remedial agents and in pharmaceutical practice. They are conveniently grouped as herbs, including flowering tops, and animal organisms.

HERBS

Under the description Herbs one includes drugs consisting of the entire plant, such as Irish moss and ergot and also drugs derived from flowering plants and consisting of flowering tops which include smaller stems, leaves, flowers and fruits, as well as others consisting of all parts of the plant growing above the ground level, such as lobelia, and in some instances also the root and rhizome. All these plant members, occurring in herbs, except the main axis itself, have already been discussed in previous chapters. The axis in herbs consists almost entirely of stem, the root or other underground structure only rarely being present.

The type of stem is that known as a **herbaceous stem**, of which there are two main types, viz., (1) the stems of annual plants such as stramonium, and (2) the stems of second year plants of biennials such as digitalis and of herbaceous perennials, which have perennial root-stocks and throw up aerial shoots annually, as does belladonna. In all cases the stems die down at the end of the season and consequently, if they are dicotyledonons, cambial activity is limited to one season or part of a season; in some such plants cambium is wanting between the primary bundles, as in species of *Ranunculus* and in the aerial stem of *Podophyllum* where, moreover, the bundles are very numerous and show a scattered arrangement as in monocotyledons. In many herbaceous stems, the vascular tissues are ill-developed.

Herbaceous stems afford many useful characters for the identification of the drugs to which they belong. The **shape** may be *terete* or nearly cylindrical as in chiretta and euphorbia pilulifera; *winged* as in lobelia and broom, *pentagonal* or five-sided as in broom; more or less collapsed and grooved due to shrinkage during drying as in belladonna and henbane. The **colour** may be green as in broom; pale green with purple patches as in lobelia; brownish with purple patches as in euphorbia pilulifera. The **surface** may be glabrous as in chiretta or more or less hairy as in lobelia and euphorbia pilulifera. The **phyllotaxis** is also a good character as in lobelia where it is $\frac{1}{3}$; in chiretta and euphorbia pilulifera opposite and decussate; in broom $\frac{2}{5}$; in belladonna $\frac{2}{5}$ or $\frac{3}{8}$. The **transversely cut surface** and the pith both give diagnostic characters. The transverse surface is always studied in the internodes and shows a characteristic outline, *e.g.*, circular in chiretta; pentagonal in broom. **The pith** may be solid as in chiretta, or have a central hollow as in belladonna and henbane

The **root**, when present, is usually a tap root and may be vertical as in lobelia or oblique as in chiretta.

Histology. Roots are so rarely present in herbs and form so small a proportion of the drug when they occur, that their histology need not be discussed at this stage. Since also leaves, flowers, seeds and fruits have been discussed previously, attention may now be limited to the histology of the stem. The majority of the tissues of the stem have also been considered above, viz., xylem, phloem, cortex, epidermis, phellogen and tegumentary developments from the phellogen. What is now required is to discuss more especially the arrangement of these tissues in herbaceous stems and to deal in detail with the endodermis and pith.

Structurally the **herbaceous stem** consists of a ground tissue in which conducting vascular strands or bundles are embedded. The main axial bundles run vertically through the internodes in many dicotyledonous stems, such as *Cannabis* and *Grindelia*, but in other examples there are no separate bundles, the vascular tissue being developed as a cylinder of xylem surrounded by a cylinder of phloem as in *Digitalis* and *Belladonna*. In other words, in the case of dicotyledons, either separate procambrial strands arise and develop into a ring of discrete bundles or a complete cylinder of conducting tissue is developed as the primary formation. In the majority of stems having separate or discrete bundles, these eventually become united into a continuous cylinder by the formation and activity of interfascicular cambium, as in *Lobelia*, *Grindelia* and *Cannabis*. In a few plants, such as *Ranunculus* and *Podophyllum*, the bundles are permanently separate. The main axial strands or cylinder is surrounded externally by a pericycle and an endodermis. The pericycle and all tissues within it are known collectively as the **stele** and the tissues external to the pericycle constitute the cortex, the innermost layer of which, termed the **endodermis**, is frequently specially differentiated. In stems, the xylem does not reach to the centre, which is occupied by a region of fundamental tissue, of greater or less extent, termed the **pith or medulla**. At or near the nodes, openings or gaps are formed in the stelar cylinder to allow branches of the conducting tissue to be separated and to become united across the cortex with the foliar strands developed in the leaves and petioles. The gaps in the vascular cylinder are termed **foliar-gaps** and the small branches passing into the leaves are the **leaf-trace** bundles.

Monocotyledonous stems have a less regular arrangement of vascular strands. The leaf-trace bundles pass independently into the stem in a slightly downward sloping direction and cross the endodermis into the pith, then they turn slowly outwards and downwards in steeply sloping lines, fusing eventually near the endodermis with other bundles much lower down the stem. One therefore finds bundles in both the cortex and [illegible] therefore [illegible], usually *connected by interfascicular cambium, or a continuous even band of* xylem and phloem or a band of xylem and phloem having projections of xylem—that of the primary bundles—into the pith. In *monocotyledons*, [illegible]

Transverse sectional views of herbaceous stems of angiosperms show, therefore, characteristic and well-marked differences both in the shape of their outlines, which may be circular, square, five-sided, winged, etc., as well as in the distribution of the vascular tissues.

The endodermis and the pith are the two tissues which still remain for a more detailed description. The **endodermis** is not always evident as a distinctly differentiated layer, but in most dicotyledons it can be recognised

[illegible]

round the four radial walls; this band is known as the casparian strip. In transverse sections the casparian strip appears as a bright spot upon the radial walls and responds to the tests for suberin and often also to those for lignin. In many plants the endodermal cells contain numerous small starch grains, which may disappear if a freshly cut specimen is kept for [illegible]

[illegible]

in the sclerenchyma as in *Erythrophleum guineense* or the sclerenchyma may be developed as isolated caps, one over each group of primary xylem as in senna stem and in *Berberis aristata*; or sclerenchymatous cells may be scattered singly or in small groups throughout a thin-walled pith as in *Coscinium Wallichianum*.

[illegible]

confusion with another type of phloem named interxylary phloem. In plants belonging to the Cucurbitaceæ this phloem occurs in masses each of which is the internal phloem of a bicollateral vascular bundle. Many plants, however, notably those belonging to the Solanaceæ, Convolvulaceæ, Leguminaceæ, Myrtaceæ, Apocynaceæ, Asclepiadaceæ, Gentianaceæ and Euphorbiaceæ, show no such regular arrangement, but the groups of sieve-tissue are of various dimensions and occur at irregular intervals in the periphery of the pith.

The cells of [illegible] starch, mucilag[illegible] of the stem of [illegible] in I bed lasts in the pith of belladonna stem, in cluster crystals in the pith of cannabis and in prisms in the pith of andrographis.

Classification of Herbs

Thallophyta

- *Algæ.* Bladderwrack, Carrageen.
- *Fungi.* Yeast, Ergot, Penicillium.
- *Lichenes.* Iceland Moss.

Bryophyta

- *Musci.* Sphagnum

Spermaphyta

- *Gymnospermæ.* Savin, Ephedra.
- *Angiospermæ.*
  - Resinous Herbs: Indian Hemp, Grindelia
  - Non-resinous Herbs: Broom Tops, Lobelia, Chiretta, Euphorbia Pilulifera, Belladonna, Stramonium, Datura, Henbane

BLADDERWRACK. Fucus vesiculosus

Sources. Bladderwrack, ***Fucus vesiculosus*** Linn., family Fucaceæ, is a seaweed of the group Phæophyceæ or brown seaweeds. It grows freely on the coasts of Great Britain and of the Atlantic Ocean generally, being found attached to rocks and stones between high and low watermarks.

Collection. At low tide the entire living plants are cut from their anchorage and dried. Plants thrown up by the sea are rejected because the cell-contents tend to diffuse out into the seawater as the protoplasm dies.

FIG. 105. Bladderwrack. Branch with reproductive organs. Natural size. (Maisch.)

Description. The fresh plants are olive-brown and about 30 to 100 cm. long; the thallus becomes cord-like in the basal part, but the upper parts, which are repeatedly branched dichotomously, are flat and about 1·8 to 2·0 cm. wide. The branches all lie in the same plane and the thallus is thickened along the central line, giving the appearance of a midrib which bifurcates at angles of 30 to 40 degrees and extends in a gradually tapering form into the apices of the branches. The margin is entire and waved because of the enlargement of the thallus at intervals by the presence of ovoid air-vesicles, about 1 to 1·7 cm. in length, in pairs, one member of each pair on either side of the pseudo-midrib. The tips of some of the branches are enlarged to an ovoid shape from the presence of numerous conceptacles—the reproductive organs—embedded in the thallus.

When dried the plants become dull brown to nearly black and hard and brittle in texture; if allowed to become damp they are cartilaginous. The odour of the drug resembles that of seaweed and the taste is saline, disagreeable, mawkish and mucilaginous.

Constituents. Bladderwrack contains a large proportion of a pectic substance named *algin* or *fucin*, which is the calcium salt of alginic acid. On hydrolysis alginic acid yields rhamnose and fucose, which is a methyl-pentose. In addition the drug yields 1·6 to 3·0 per cent. of ash in which iodides, chlorides and bromides are present. The iodine in the drug amounts to about 0·04 per cent. and is regarded as the important medicinal constituent.

Alginic acid is prepared commercially by macerating seaweed in water and boiling the insoluble residue in a solution of sodium carbonate; the alginic acid dissolves and is precipitated from the filtered solution by *hydrochloric acid*; the precipitate is redissolved in soda and the solution evaporated on glass plates; it is used as a calico dressing and for thickening the colours used in calico printing.

Varieties. *Fucus serratus* Linn., also a common seaweed occurring with *F. vesiculosus* on the rocky shores of Great Britain, has a serrated margin and no air-vesicles, whilst *Ascophyllum nodosum* Linn. has the vesicles single. The constituents of these seaweeds are probably similar to those of *F. vesiculosus*.

Use. Preparations of bladderwrack have been used medicinally to reduce obesity.

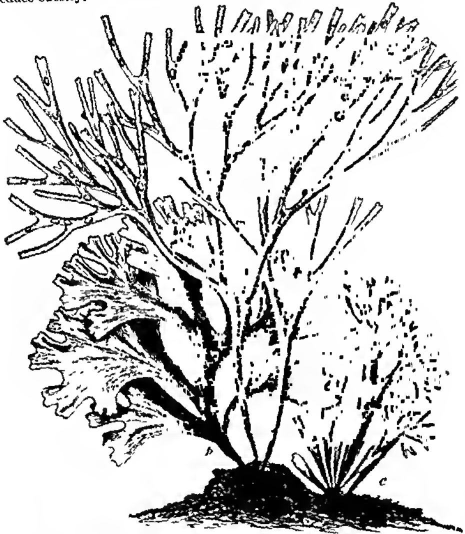


FIG. 106. Irish moss (*Chondrus crispus*) Three different forms of the plant, *a*, *b*, *c*; *a* with cystocarps embedded in the thallus; natural size. (Luerssen.)

CARRAGEEN. Chondrus; Irish Moss

Source, etc. Irish moss, *Chondrus crispus* Stackhouse, family Gigartinaceæ, is a seaweed of the group Rhodophyceæ, the red seaweeds. It is widely distributed on the northern shores of the Atlantic Ocean and abundant on the coasts of Ireland and Scotland, growing from three-quarters tide level to below low-water mark.

Collection. It is collected for medicinal use on the north-western coast of Ireland, the coast of Brittany, and of Massachusetts in the United

States. The plant is removed from the sea by raking. When fresh it varies in colour from green to dark purple, but is bleached by exposing it to the sun and watering it, the colouring matter, which is soluble in water, being partly washed out and partly destroyed by the treatment. The bleaching is said to be completed by chemical means.

Description. Plants of *Chondrus crispus* are from 5 to 10 cm. long, being attached to stones and rocks by the cord-like lower portion of the thallus. The plant branches very regularly to form a dichotomy, the ultimate ramuli being about 2 mm. wide. Three types of plant occur; in one the branches are all slender and elongated in a second the basal parts are flat and broad and the terminal branches small and narrow, in a third all parts are broad and flat with very short and broad ultimate branches. In the thallus of many of the plants small ovoid swellings are present resulting from the formation of cystocarps, which are the fructifications containing spores. Often the cystocarps have fallen out, leaving corresponding oval perforations in the ramuli.

The drug, which consists of the dried seaweed, is yellowish-white, translucent and horny, but cartilaginous when moist. It has a slight odour of seaweed and a mucilaginous, saline taste. A decoction made with twenty times its weight of water solidifies on cooling to a jelly, which is not stained blue by iodine (distinction from Iceland moss jelly).

Constituents. Irish moss contains two pectinous substances, one extractable by cold water and not yielding a jelly when the solution is concentrated and cooled, the other extractable by hot water and yielding a stiff jelly in a 2 per cent. concentration. Hydrolysis shows that these substances are calcium salts of acid esters of sulphuric acid, $R(O.SO_2.O)_2Ca$, the organic radicles yielding galactose, glucose, fructose and arabinose. The mucilaginous material obtained from Irish moss was formerly named carrageenin. The drug also contains about 7 to 9 per cent. of protein and yields 8 to 16 per cent. of ash in which small amounts of iodides and bromides are present together with calcium and small quantities of sodium, potassium and magnesium.

Uses. Irish moss possesses demulcent properties. It has been given in pulmonary complaints and for chronic diarrhœa, and has been used for the preparation of a nutrient jelly which, however, is not easily attacked by the digestive juices at blood temperature. It is also employed for various technical purposes, such as calico dressing, etc., as a cheap substitute for gum arabic for feeding pigs and calves and as an emulgent.

Adulterant. *Gigartina mamillosa* J. G. Agardh, which is occasionally found mixed with Irish moss, may be distinguished by its stalked cystocarps, as may also *Gigartina pistillata* Lamouroux, but the latter is a rare British seaweed and its presence would indicate that the drug had probably been collected in France.

YEAST. Cerevisiæ Fermentum, Fæx Medicinalis

Sources. Yeast consists of unicellular fungi belonging to the genus *Saccharomyces*, family Saccharomycetaceæ, a sub-division of the group Ascomycetes. Several species are used in industry, the most important being *S. cerevisiæ* Meyen *emend.* Hansen, *S. carlsbergensis* Hansen and *S. monacensis* Hansen, and of these there are several different races and strains.

Cultivation and Preparation. Yeast is grown in saccharine fluids containing suitable proportions of nitrogenous matter and inorganic salts. Such a medium is brewers' or distillers' wort, which is obtained commercially

by steeping malt or a mixture of malted and unmalted grain in water at 60° to 65°. The yeast is added to the liquor at 20° to 25° when it multiplies rapidly by the process of gemmation or budding. The yeast is skimmed off from the surface, washed in water and the liquor passed through sieves and after several more washings the yeast is allowed to settle and is removed by filter-presses, thus producing the commodity known as compressed or bakers' yeast, formerly often described as German yeast.

Description. Yeast obtained by the process outlined above is a putty-like or somewhat crumbly mass having a slight odour resembling that of beer. It consists of rounded or ovoid cells occurring either singly or in short chains, either straight or branched, which result from the process of multiplication by gemmation. The cells are colourless, about 4 to 7 to 9μ in diameter, and each has a rudimentary nucleus consisting of a nucleolus associated with a nuclear vacuole in which there are strands of chromatin; in the cytoplasm granules of glycogen and globules of fat occur. Cells which have become dry or ill-nourished may develop endospores, which are spherical, and highly refractive and form a group of four in a single yeast cell.

Constituents. Compressed or bakers' yeast contains about 73 per cent of moisture, 13 per cent. of proteins and 0·27 per cent. of oil. The yeast plant forms a number of enzymes, one of which, zymase, converts monosaccharides, such as glucose, into alcohol and carbon dioxide. Other enzymes present are invertase, maltase, diastase and endotryptase. The proteins of yeast are partly free and partly combined with nucleic acid. The carbohydrate glycogen, fat, ergosterol and zymosterol are also present.

Yeast is an important source of vitamins belonging to the vitamin B complex, including aneurin hydrochloride (vitamin B_1), riboflavin (vitamin B_2), nicotinic acid (pellagra-preventive factor), pyridoxin (vitamin B_6) and a little pantothenic acid (chick antidermatitis factor).

Yeast yields about 2·75 per cent. of ash.

Dried yeast is a buff or brownish powder obtained by drying bakers' or brewers' yeast at a temperature not exceeding 30°. Some varieties consist of dead cells and others of cells in the resting stage; the latter may resume growth when placed under suitable conditions. The cells of dried yeast may be loosely arranged or in small, more or less agglutinated, angular masses.

Dried yeast contains about 9 per cent. of moisture, 46 per cent. of proteins, 36 per cent. of carbohydrates and yields about 8·5 per cent. of ash. It contains the same vitamins as fresh yeast together with choline and ergosterol.

Storage. Dried yeast should be stored in a cool dry place and must be protected from the access of light and moisture.

Uses. The chief use of yeast is as a source of vitamin B. Dried yeast is used in many dietetic preparations.

Adulterants. Starch and flour sometimes occur as adulterants of yeast. Yeast should not contain more than 1·43 parts per million of arsenic.

ERGOT. Ergota, Ergot of Rye

Sources. Ergot is the plant *Claviceps purpurea* Tulasne, family Hypocreaceæ, in the sclerotium stage, the condition in which it passes

the winter The medicinal ergot is that formed in the diseased ovary of the rye, *Secale cereale* Linn., family Gramineæ. Ergot is imported chiefly from Spain, Portugal, Poland and Russia.

The *life history* of the fungus, which is one of the Ascomycetes, is briefly as follows. In the early summer, when the rye plants are in flower, spores carried by the wind lodge at the base of the ovary of the rye flower and germinate. The hyphæ penetrate the ovary wall and grow throughout the tissues of the ovary until the whole has been replaced by the fungus and becomes enlarged and spongy at the upper end, where the protruding hyphæ abstrict numerous spores. This condition is known as the sphacelia stage, during which the fungus secretes a saccharine fluid known as "honey-dew." Insects are attracted by the secretion and carry away the spores to other rye plants which become infected with the disease. Later in the season, as the rye ripens, a dense core of compacted hyphæ develops in the diseased ovary and grows out so as to project from the ear of rye, bearing at its apex the pale coloured remains of the sphacelia stage. This hard structure is dark purplish-brown externally and is known as the sclerotium. When the ripened rye grains fall, the sclerotia fall with them and remain in the ground through the winter. In the following spring each sclerotium germinates and sends out several upright cylindrical stalks or stromata, each about 10 to 20 mm. long. The apex of each stroma swells into a spherical head, about 2 mm. in diameter, in which are embedded a number of flask-shaped cavities named perithecia. Each perithecium contains numerous elongated asci or sporangia in each of

[illegible] new crop of rye, which will now be at the flowering stage.

Cultivation and Collection. Experiments in the cultivation of ergot have been successfully made both in Austria and in Australia. Ergots are sown in boxes of sandy earth and are exposed in the open to the winter frosts. In the spring they germinate and the ascospores are sown upon a nutrient gelatin in Petri dishes, where they germinate readily and form colonies. The colonies are cut out and transferred to a fluid medium in large flasks, where great numbers of spores are developed. The diluted [illegible]

Description. Ergots are dark-purple to nearly black externally, about 1·5 to 4 cm. long and 1 to 6 mm. thick, fusiform or sub-cylindrical with tapering ends, often arcuate and somewhat three-sided with a shallow groove along each face; the pale-coloured remains of the sphacelia stage ma[illegible] resent at the apex. The fracture is short and the exposed surf[illegible] 'te or pinkis[illegible]ften showing a few slightly darker lines rad[illegible] the cent[illegible] uter margin is purplish-violet. The tast[illegible] nt and [illegible] d the odour is disagreeable and faint, [illegible] e inten[illegible] rushing the drug with s[illegible] on of a ca[illegible] The de[illegible] t is about 1·02.

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origin from the septate hyphæ arranged more or less parallel to one another. The walls and contents of this outer layer are dark purplish and change to blood-red with acids and violet with alkali, a reaction due to sclererythrin. The inner part of the sclerotium is of a similar structure throughout and in section the cells are small, about 3 to 12μ wide, unequal in size, rounded, with thick walls which are very highly refractive. Between the cells intercellular spaces are rare except in the centre where the cells are often connected by short arms and spaces are present; it is these regions of

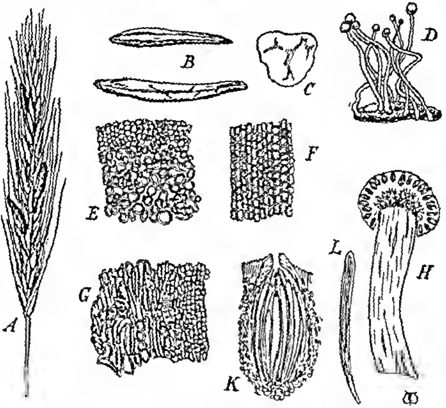

FIG 107 Ergot *Claviceps purpurea*. *A*, ear of rye with ergots × ½ *B*, ergots × 1. *C*, Transversely cut surface of a sclerotium × 2. *D*, germinating ergot with stromata × 1. *E*, transverse section of a sclerotium × 250 *F*, surface of sclerotium × 250 *G*, longitudinal section of sclerotium × 250 *H*, longitudinal section of a stroma, showing perithecia embedded in the head × 12 *K*, a perithecium containing numerous asci × 150. *L*, an ascus with filamentous ascospores × 200.

more loosely arranged cells which give the appearance of darker radiating lines in the fractured surface. The contents of the cells consist of protoplasm with fixed oil and protein forming an oil-plasma. The cell-walls respond to the reactions for chitin. There are no crystals, starch granules or spores.

Note on Chitin. Chitinised cell-walls do not give the ordinary reactions for cellulose or lignin or cutin. They dissolve completely in sulphuric acid (80 per cent by volume) and are identical with the substance of which the exoskeleton of insects is composed. Chitin is a polysaccharide derivative, containing amino and acetyl groups. When heated with concentrated

caustic alkali at 110° to 180° C. for about thirty minutes it breaks down into chitosan and acetic acid.

Chitosan, which is also known as mycosin, is decomposed by strong hydrochloric acid into glucosamine and acetic acid. Chitin can therefore be identified by converting it into chitosan and testing for chitosan by soaking it in iodine water and then adding 10 per cent. sulphuric acid when a deep violet coloration is given to the chitosan. The chitosan will also dissolve completely in 50 per cent. nitric acid and the chitosan-nitrate can be crystallised out in sphere crystals which polarise with crossed nicols to show a distinct cross.

Constituents. Ergot contains three crystalline alkaloids, ergotoxine, ergotamine and ergometrine, all of which are physiologically active and contract the muscle of the uterus. The amount of ergotoxine present is about 0·1 to 0·2 per cent. All three alkaloids are converted by comparatively simple treatment into inactive alkaloids named ergotinine, ergotaminine and ergometrinine respectively; these inactive alkaloids may be obtained during the extraction of the constituents of ergot. All these six alkaloids are derivatives of lysergic acid, showing their close interrelationship. Ergot also contains tyrosamine, histamine and very small amounts of isoamylamine and acetylcholine. The colouring matter present consists of a red substance sclererythrin and a yellow body secalonic acid. In addition ergot contains about 30 to 40 per cent. of fixed oil or fat which yields on saponification about 1 per cent. of sterols of which ergosterol is the most important.

A new alkaloid, ergosine, has been isolated by Smith and Timmis (1936) and ergotoxine has been shown to be a mixture of three isomorphous alkaloids named ergocristine, ergokryptine and ergocornine (Stoll, Hofmann and Becker, 1943).

Storage. *Ergotoxine is a white crystalline substance and is rather* unstable; it darkens on exposure to air and light and it deteriorates in the presence of moisture and at a raised temperature. The oil in ergot, especially in powdered ergot, gradually becomes rancid, a *change which is accompanied by a simultaneous loss of active con*stituents. Ergots, especially if they are at all damp, are also very prone to attack by moulds, mites and insects such as small beetles and moths.

To keep ergot in good condition it should therefore be stored in containers which exclude the light and are well-closed and kept in a cool, dry place. These conditions are satisfied by the use of tins with well-fitting lids or of amber-glass bottles with good screw-on bakelite caps. The ergot so stored should have been previously thoroughly dried and must consist of undamaged entire ergots. If *powdered ergot* is to be stored, the fat must first be removed by the use of a suitable solvent such as light petroleum. The containers should be well filled and, as far as possible, should contain quantities which are likely to be used at one time or on a few occasions only, so as to avoid leaving the containers partly filled. Ergot stored as suggested will keep well.

It has been customary in some warehouses to add some preservative to ward off the attack of insects; camphor, chloroform and a globule of mercury have been used in this way and appear to be effective. It is,

however, preferable to store ergot, if possible, without the addition of preservatives.

Uses. The chief action of ergot is the stimulation of plain muscle, especially of the uterus and of the arterioles in peripheral parts of the body; it is employed to excite or increase uterine contraction and to control uterine hæmorrhage.

Substitutes. Ergots are formed in the inflorescences of many grasses, some of the more important are: Ergot of wheat on *Triticum sativum*, which is shorter and thicker than that of rye; ergot of marram grass, *Ammophila arundinacea*; ergot of rye-grass, *Lolium perenne*; ergot of festuca, *Festuca elatior*; ergot of oats, *Avena sativa*, which is black, about 10 to 12 mm. long and 3 to 4 mm. thick and is used in Algiers; ergot of diss, *Ampelodesma tenax*, which is spirally twisted and about 9 cm. long and comes from northern Africa.

Factitious ergots have been prepared by moulding ordinary wheat dough into the form of ergots and colouring them externally, which may be done by dipping the dough into red ink and then into black ink.

PENICILLIUM

Sources. Penicillium is the mould fungus *Penicillium notatum* Westling, ... es of the fungi. ... ound growing up ...

Description. When the mould is ...

... the central part becomes older, fructifications are produced and the colour changes to bluish-green, due to the colour of the spores or conidia. The undersurface of the colony is yellow in colour. A colony ...

... *Penicillium notatum* grows well on an agar medium, such as nutrient ...

... sulphate 0·01; glucose 40; water to 1,000. Some workers prefer to use a considerably larger proportion of phosphates to buffer the solution and so increase the yield of penicillin; traces of zinc salts are ...

... are about 5μ wide (*i.e.*, ... ome) and they become twisted together to form a delicate white felt or mycelium. From this mycelium there arise vertical fruiting branches known as conidiophores, which are about 3μ to 5μ thick and may be as long as 0·75 mm. The ...

... The group of

metulæ forms a verticillus (verticil) and the whole fructification which bears a resemblance to a camel-hair brush or pencil gives rise to the generic name *Penicillium* from the Latin penicillus, an artist's paint brush.

The arrangement and lengths of the branches of the penicillus and the diameter and shape of the spores provide details by which the numerous species of *Penicillium*, of which there are nearly 700, are distinguished. In *P. notatum* the metulæ are 3μ to 6μ wide and 10μ to
long;
somew
P. notatum differ in the power of producing penicillin. Active strains deteriorate by continued sub-culturing. The dried spores keep well and show no deterioration.

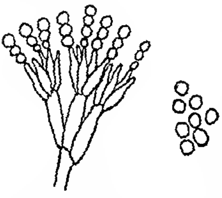

FIG. 108. *Penicillium notatum*, penicillus and spores. × 1,000 (after Westling).

Constituents. It was noticed by Professor Sir A. Fleming that a colony of *P. notatum* growing on an agar culture of staphylococci

production by the mould of an antibiotic or bacteriostatic principle, which has been named penicillin. Penicillin is an unstable acid secreted by the plant into the culture medium and is usually obtained by the use of a fluid (modified Czapek's) medium. Sodium, calcium and barium salts of penicillin are prepared and used for administration. A filtered culture has also been successfully used for the treatment of wounds.

CETRARIA. Iceland Moss

Sources. Parmeliaceæ, is a foliacec ly distributed over the n Sweden and Central Europe, growing usually amidst moss and grass on the lower mountain slopes.

Description. The drug consists of pieces of the dried foliaceous lichen about 5 to 12 cm. long with numerous ascending branches arranged in an unevenly developed dichotomy. The branches are thin, about 6 mm. wide and 0·5 mm. thick, and have spinulose margins, that is, fringed with minute projections, each of which bears a small spermogonium at its apex. The plant is opaque, harsh and springy to the touch, greenish-brown to brown above and greyish below with small, white, ovoid depressed spots. Apothecia are not uncommon and occur as dark brown marginal discs nt present is a unicellular sub- The drug is almost odourless

two complex carbohydrates, lichenin about 40 per cent. and isolichenin about 10 per cent. Lichenin dissolves in boiling water and the solution gelatinises on cooling and does

not give a blue colour with iodine; isolichenin, also named dextrolichenin, is soluble in cold water and the solution gives a blue colour with iodine. On hydrolysis lichenin yields α-glucose and isolichenin yields mannose, galactose and glucose. The drug also contains bitter [illegible] protocetraric acid which [illegible] crystal [illegible] hydr [illegible] 2 to [illegible]

A [illegible] 1 to 20, yields on cooling, a jelly which is colour[illegible] blue by iodine and may be thus distinguished from the jelly obtained from carrageen.

FIG. 109. Iceland moss (*Cetraria islandica*). Natural size. (Luerssen.)

The bitterness of the drug can be removed by soaking it in a dilute solution of sodium bicarbonate, but such preparations are merely demulcent, having been deprived of their tonic properties, and are no longer capable of increasing the peristalsis of the stomach and bowel.

Uses. Iceland moss is used as a bitter stomachic and tonic and to yield a demulcent and nutrient jelly.

SPHAGNUM. Peat Moss, Bog Moss

Sources. Peat moss consists of various species of *Sphagnum* Dill., family Sphagnaceae. The species preferred for pharmaceutical use are the long-stemmed ones such as *S. cymbifolium* Ehrh., *S. subsecundum* Nees, *S. acutifolium* Ehrh., and *S. cuspidatum* Ehrh. These are collected on the moors of Devonshire, Dumfriesshire, and the Western Highlands. Sphagnum moss occurs throughout the northern hemisphere generally and other suitable species are also used in other countries.

Collection and Preparation. The moss is removed from the bogs in which it grows and the water is squeezed from it; it is then spread out so that warm dry air may pass over it and render it air-dry. If completely

FIG. 110 Sphagnum moss. *A*, *S. cymbifolium*, habit sketch, natural size. *B*, branch of the same × 5. *C*, leaves of the same × 10. *D*, leaves of *S. acutifolium* × 10. *E*, leaves of *cuspidatum* × 10. *F*, leaves of *S. subsecundum* × 10. *G*, branch of *S. acutifolium* × 5. *b.l*, branch leaf; *c*, chlorophyllose cell; *c.b.*, abaxial surface of leaf; c.d., adaxial surface of leaf; *h*, hyaline cell; *s.l.*, stem leaf; *t.s.*, transverse ... (*C* after Dixon and Sherrin; *D*, *E* and *F* ...

dried by artificial ... become air- ... condition a ... foreign moss ... phanerogamous plants and ... thickness. ... compressed into sheets about 5 to 10 mm. in

Description. Sphagnum plants have slender thread-like stems, about 10 to 30 cm. long, which bear small leaves and branches in groups or fascicles of three to twelve at intervals of 4 to 6 mm. Some of the branches of each group are pendent, longer and flagelliform, others are upright, divergent and rather stouter. At the apex of each stem the branches are crowded together forming a compact head or capitulum. In some of the capitula one may find small stems bearing chestnut-brown, globose or ellipsoidal capsules, usually about 2 to 4 mm. long and 2 mm. wide. Both the main axis and the branches bear leaves, those of the axis being colourless and those of the branches faintly green. The shapes and sizes of the two types of leaves are different as illustrated in the following particulars of the four named species. See Fig. 109

S. cymbifolium. Plants about 15 to 20 cm. long; stem leaf broadly lingulate or broadly spathulate, 2 mm. long and 1 mm. broad; branch leaf broadly ovate narrowing to a cucullate or hood-shaped apex, 2 mm long and 0·8 mm. wide.

S. subsecundum. Plants 10 to 30 cm. long; often red-brown or orange, not rose; stem leaf oval-deltoid to oblong lingulate, 1·0 mm. long and 0·5 mm. broad; branch leaf broadly ovate to oblong lanceolate, acuminate or obtusely pointed, 2 mm. long and 1 mm. broad.

S. acutifolium. Plants 7·5 to 30 cm. long; tufts soft, pink, pale green or whitish, male branches always red; stem leaf triangular to lingulate, 1 mm. long and 0·5 to 0·8 mm. wide at the base; branch leaf oval to narrowly oval-lanceolate, truncate and toothed at the apex, 1 to 1·6 mm. long and 0·4 to 0·5 mm. broad.

S. cuspidatum. Plants 15 to 45 cm. long, pale green or pale brown; stem leaf deltoid or ovate-triangular, 1·2 mm. long and 0·8 mm. wide at the base; branch leaf lanceolate to narrowly lanceolate, 1·8 to 2·3 mm. long and 0·5 mm. wide at the base.

Histology. The leaves of both the stem and the branches are one cell in thickness throughout. The leaves of the branches are composed of two kinds of cells; the cells containing the chlorophyll are very narrow and are arranged in the form of a network, each of the meshes of which is filled by a large sinuously rhomboidal or elliptical cell, the wall of which is strengthened by a loosely spiral thread of thickening and has one or more large rounded perforations. The leaves of the stem or main axis are composed entirely of hyaline cells, possessing much fewer thickening threads and pores or entirely devoid of these structures.

Constituents. Sphagnum contains a phenolic substance named sphagnol, to which its antiseptic property is ascribed.

Uses. Sphagnum moss is used for making absorbent dressings by enclosing definite weights of moss in muslin bags of particular sizes. In the form of compressed sheets it is used as an absorbent mattress to take up urinary and similar discharges. In addition to acting as an absorbent, it is regarded as possessing antiseptic properties.

EPHEDRA. Ephedra. Ma Huang

Sources, etc. Ephedra, although of recent introduction into European medicine, has been used in China since very ancient times under the name of Ma Huang. It is derived from *Ephedra sinica* Stapf, *E. equisetina* Bunge, both indigenous to China; *E. Gerardiana* Wall. indigenous to India; and *E. nebrodensis* Tineo (= *E. Scoparia* Lange), indigenous to India and Spain, plants belonging to the family Gnetaceæ.

Collection and Preparation. The young and slender green twigs are collected in the autumn and dried. They are either exported loose in sacks, when they are usually attached in groups to a small portion of the

FIG 112 Indian hemp; cannabis *A*, habit sketches and floral diagram of female inflorescence *B*, bract and its pair of bracteoles, each with a ♀ flower in the axil, × 4 *C*, simple lanceolate bract × 4 *D*, a ternate bract × 4 *E*, pistillate flower × 4 *F*, full grown fruit surrounded by its bracteole × 4 *G*, transverse section of a bract × 150 *H*, glandular trichome × 150. *K*, part of a stigma × 75 *ax*, axillary shoot, *b*, bract, *bl*, bracteole, *cu*, cuticle; *cy*, cystolith; *fl*, flower; *o*, ovary, *ov*, ovule, *pg*, perigone; *sp*, stipule; *st*, style and stigma; α and β, the two bracteoles

sessile or palmately compound with three leaflets and shortly petiolate, each has two small subulate stipules, the laminæ are lanceolate and have entire margins and are usually from 15 to 20 mm long and

2 to 4 mm. wide. The lower bracts are somewhat larger and resemble the foliage-leaves, they are palmately compound with three to five leaflets which are narrowly lanceolate, with serrate margins and acute apices, the central and largest leaflet being about 3 cm. long. In the axil of each bract are two boat-shaped bracteoles with acute apices, each enclosing a single small pistillate flower. The flower consists of an ovary closely enveloped by a membranous perianth, termed a perigone, and the ovary is about 2 mm. long and is surmounted by two long brownish-red hairy stigmas; within the ovary is a single ovule. A few fruits are usually present, each being 5 to 6 mm. long and 4 mm. wide, ovoid with several longitudinal veins due to the presence of the enlarged, persistent bracteole enveloping the fruit. The single oily seed fills the loculus and contains a large embryo and a very scanty endosperm.

Cannabis from America and Africa occurs as loose fragments which are less resinous than the Indian drug and therefore do not adhere in masses. Amongst the fragments all the structures described above are to be found. African cannabis is usually dusky green in colour; American cannabis is usually bright green.

All parts of the plant, but particularly the bracts, stipules, and upper leaves, bear numerous hairs and large stalked glands, the latter secreting a quantity of viscid, adhesive resin.

The drug has a heavy powerful odour, but is almost devoid of taste.

Histology. The leaves and bracts have the structure of an ordinary dorsi-ventral leaf. The palisade consists of a single layer, rarely two, of cylindrical cells and the spongy tissue of two to four layers of rounded parenchyma; cluster crystals of calcium oxalate are present in all parts of the mesophyll. The upper epidermis has cells with straight anticlinal walls and bears unicellular, sharply pointed, curved conical trichomes, about 150 to 220μ long, with enlarged bases in which are cystoliths of calcium carbonate; it also bears numerous glandular trichomes of the type described below. The lower epidermis bears conical trichomes which are longer, about 340 to 500μ long, and more slender, but without cystoliths; it also has, especially over
a secreting head of about
secrete an oleo-resinous flu
as a delicate covering envelope. Some of the glands are sessile and others have a cylindrical, multicellular stalk, about 200μ long and several cells
under
H.
layers
of cells, the lower hypodermal layer having a cluster crystal of calcium oxalate in almost every cell. The under or outer surface bears very numerous glandular trichomes and also unicellular conical trichomes, which are numerous on the bulging part, but are scattered thinly elsewhere. Abundant smaller unicellular conical hairs occur all over the upper or inner surface. The stigmas have an epidermis nearly every cell of which is extended as a unicellular papilla about 90 to 180μ long with a rounded apex.

The slender stem axis has well-developed bundles of pericyclic fibres behind the phloem bundles; there are large laticiferous tubes in the phloem and calcium oxalate in cluster crystals, about 25 to 30μ in diameter, in both the pith and the cortex. The epidermis bears trichomes similar

to those of the leaves. These laticiferous tubes are unbranched and each is formed from a cell in the growing point of the shoot and the cell continually elongates so as to keep pace with the growth of the plant.

Constituents. The resin has been obtained as a soft brown substance, cannabinone, from which, by distillation *in vacuo*, a pale yellow viscous substance, cannabinol, which melts to an oily liquid when warmed has been separated. Cannabinol produces a powerful narcotic action and is believed to be the active constituent of the drug. On exposure to the air it resinifies rapidly and becomes brown.

In addition to cannabinol and resin, the drug contains the alkaloid choline and traces of volatile oil; it yields from 10 to 18 per cent. of alcoholic extract and about 15 per cent. of ash

A diagnostic chemical test is to add a 15 per cent. solution of gaseous hydrochloric acid in dehydrated alcohol to a light petroleum extract of the drug. A red coloration appears at the junction of the liquids and after shaking the upper layer becomes colourless and the lower acquires an orange-pink coloration which disappears on the addition of water.

Another test is to extract with methyl alcohol, filter and evaporate to dryness with a little sand, extract the residue with light petroleum, filter into a separating funnel and extract successively with 5 per cent. sodium carbonate and 5 per cent. sulphuric acid, wash with water, decolorise with animal charcoal if necessary and evaporate the filtrate. Add to the residue a few drops of N/10 alcoholic caustic potash when a purple colour is given (Fahmy 1935, modified from Beam).

Storage. When cannabis is kept under ordinary conditions, without special precautions, the drug gradually deteriorates, possibly owing to the action of oxydases upon the resin. This deterioration is well-known in India and addicts to the drug refuse supplies which are older than one year. To avoid the detrimental action of oxidation, the drug must be thoroughly dried and stored in well-closed containers.

Uses. Indian hemp acts upon the nervous system, producing first excitement accompanied by hallucinations and afterwards lethargy and sleep It is used as a sedative in mania and hysteria, as well as for spasmodic cough, asthma, neuralgia, etc.

Other Products of *Cannabis sativa*

Bhang consists of the leaves and young tops of male or female plants collected green and dried. Most of it is used in India and Egypt for making complex electuaries and for preparing drinks by macerating the pounded bhang in water.

Churrus or *Charas* is the resin collected by beating the plants on cloths to which the resin adheres. It is purified by warming and pressing through cloth to remove vegetable débris. It is usually smoked or made into preparations

Haschisch is a name given to the plant itself and also to an electuary made by digesting the herb in butter. It is used for producing an agreeable form of intoxication.

GRINDELIA. Herba Grindeliæ

Sources, etc. The drug consists of the dried leaves and flowering tops of *Grindelia campōrum* Greene, family Compositæ, the common "gum plant" of California, and is collected near San Francisco Part of the drug is said to be derived from *G. cuneifōlia* and its variety *paludōsa*; the leaves

of these plants are cuneate and less coriaceous than those of *G. camporum*.

Before the flowerheads expand they secrete a white sticky resin; in May and June the whole plant is resinous, and then the leaves and flowering tops are collected and dried.

Description. The commercial drug consists of the upper part of the flowering stem, together with the flowerheads and a few leaves.

The *stems*, often 50 cm. in length, are up to 2 mm. in diameter, yellow smooth, sub-cylindrical and have a large pith. They bear alternate, pale green leaves, which, however, are easily broken off, and therefore frequently lie loose in the package. The *leaves* are oblong to lanceolate-spathulate, 3 to 6 cm. long, with an acute apex and a serrate margin; they are rigid, brittle, smooth, sessile, and sometimes amplexicaul, and have a glabrous, minutely dotted surface. The *flowerheads* are sub-conical, yellowish, hard and resinous, and are surrounded by four or five rows of lanceolate-acuminate, imbricated, bracts with recurved linear tips; the receptacle is flat. They contain numerous compressed fruits, each crowned by two stiff, thick bristles, and when mature is bi-auriculate or more rarely uni-dentate at the summit.

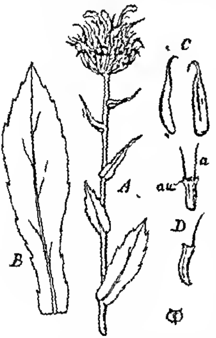

FIG 113. *Grindelia camporum.* *A*, upper part of stem with capitulum. *B*, lower foliage leaf. *C*, two bracts from the involucre. *D*, two cypselæ, upper one from the centre, lower one from the ray. *a*, awn, *au*, auricle. *A* and *B* natural size. *C* and *D* × 5.

The under surface of the involucral bracts bears numerous external glands which secrete resin; there are also internal schizogenous ducts which contain a similar, though not identical substance. External resin-glands are also found on the leaves.

The drug has a slight odour and a somewhat balsamic taste.

Constituents. The chief constituents of grindelia are amorphous resins (up to 21 per cent.). These include a soft, greenish resin soluble in petroleum spirit and two dark coloured resins, one of which is soluble in ether. To these resins the activity of the drug appears to be due (Power and Tutin, 1905). The drug also contains a considerable quantity of *l*-glucose, tannin (1·5 per cent.), and a trace of volatile oil. It leaves about 8 per cent. of ash.

Uses. The drug has the reputation of being almost a specific for certain forms of asthma, and has been recommended for cystitis and catarrh of the bladder.

BROOM TOPS. Cacumina Scoparii, Sarothamni Herba

Sources. Broom tops are the young green twigs of *Cytisus Scoparius* Link., family Leguminosæ, gathered in the early spring before the plant has flowered and used either fresh or after careful drying away from the light. The plant is a shrub growing to a height of 1 or 2 metres, the older parts of the stem being hard and woody It is indigenous to Britain and occurs throughout temperate Europe from the western coasts to Poland and Hungary.

Description. The *axis* of the young twigs is slender and five-angled,

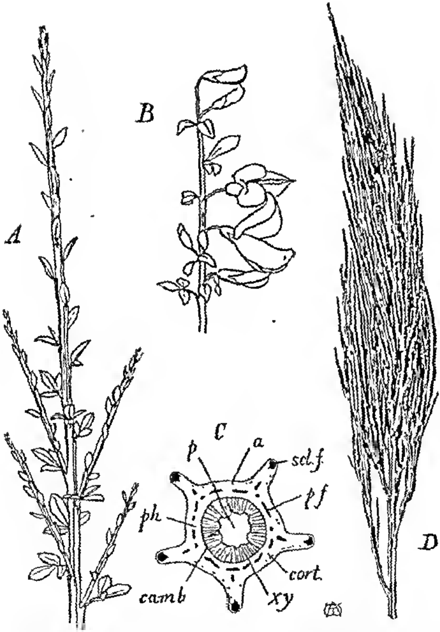

FIG. 114. *Cytisus scoparius* Link. Broom tops. *A*, young twig, showing simple sessile leaves on the upper part and compound ternate leaves on the lower part *B*, small flowering shoot. *C*, diagrammatic drawing of a transverse section of a twig about one year old × 15 *a*, assimilating tissue; *camb*, cambium, *cort*, cortex, *p*, pith; *p.f.*, pericyclic fibres; *ph*, phloem; *scl.f*, sclerenchymatous fibres; *xy*, xylem *D*, commercial dried broom tops × ½. (*D* from *Pharm Journ.*)

about 1 to 4 mm. in diameter, and has slight wings on the angles. The phyllotaxis is 2/5 and the internodes are from 2 to 10 mm. long. The *leaves* on the lower part of the twig are shortly petiolate and ternate with small oval-oblong leaflets about 5 to 10 mm. long; those of the upper part are simple and sessile, about 4 to 7 mm. long, and lanceolate. The leaves are att[illegible] frequently fall off during drying [illegible] The *flowers*, when present, are [illegible] ey-like odour, and are borne on [illegible] are monadelphous and the calyx is two-lipped, the posterior lip having two teeth and the anterior three teeth; the style is curved to form a complete circle. The po[illegible]

dis[illegible]

Constituents. The chief constituents of broom are a liquid volatile alkaloid, sparteine, and a yellow, crystalline flavone, scoparin; in addition to these a crystalline, volatile alkaloid, genisteine, and a non-volatile alkaloid, sarothamnine, have been isolated from it.

Uses. Broom is used as a heart tonic and a diuretic in dropsy, but it appears to have but little action on healthy individuals. Sparteine exhibits physiologically a close resemblance to coniine, but it is much less toxic.

Adulterants. Spanish broom, *Spartium junceum* Linn., has a calyx with one lip only, having five small teeth and the style is bent, but does not form a loop. The pods are nearly glabrous. The herbaceous parts of *Osyris alba* Linn., family Santalaceæ, have been substituted for broom tops; the stem is many striated (instead of five-winged); the buds are on the apex of an angle which forms a keel on the dorsal surface of the bud (instead of in a channel between the angles) and the wood is white (instead of yellowish) (Farwell, 1922).

LOBELIA. Herba Lobeliæ, Indian Tobacco

Sources. Lobelia, *Lobēlia inflāta* Linn., family Campanulaceæ, an erect annual herb, about 40 to 60 cm. high, with an acrid latex, is distributed over the eastern States of North America, and cultivated for medicinal use in the States of New York, Massachusetts and Michigan. The drug was a domestic medicine of the North American Indians, and was introduced into European practice about 1830.

Cultivation and Collection. The drug is collected from both wild and cultivated plants. For its cultivation the soil is preferably a rich loam, carefully prepared and in fine tilth. The seed is sown thinly on the surface of the soil in lines about 60 cm. apart and is pressed in firmly by placing a board over the seed and walking on it. Sowing may be done in autumn or spring, but autumn sowing gives the better crop. The harvest is made when the plants are in flower and the lowermost capsules have become inflated. The upper parts of the plants are cut down and carefully dried in the shade. The yield is about half a ton per acre.

Description. The drug occurs as a mass of the dried aerial parts of the plants packed somewhat loosely in sacks or as hard brick-shaped masses of chopped and strongly compressed herb, wrapped in paper and weighing about 250 or 500 gm. The *stem axis* is green to yellowish, usually with large purple patches; in the upper part it has two to five wings and is hairy, in the lower part it is channelled and nearly glabrous.

The *leaves* are sessile in the upper part and shortly petiolate below, they have a phyllotaxis of 1/3, and are ovate to ovate-lanceolate and about 3 to 10 cm. long; the lamina is irregularly toothed at the margin and bears scattered bristly trichomes especially over the veins on the lower surface. The inflorescence consists of several small racemes of small pale-blue flowers Each *flower*, which is about 7 mm. long, has a short pedicel, an inferior ovary, five subulate sepals, a

FIG. 115. *Lobelia inflata*. *A*, habit sketch × ¼. *B*, flower × 3 *C*, fruit × 2. *D*, transverse section of a fruit × 4. *pl*, placenta; *s*, seeds. *E*, fruit seen from above × 4, showing pores, *p* *F*, stem × 1. *wg*, wings. *G*, seed × 35 *H*, leaf × 1 (*A* and *B* after Bentley and Trimen.)

tubular bilabiate corolla, which is split nearly to the base along the central line between the two erect posterior lobes, the anterior lip has three spreading triangular-ovate lobes. The five *stamens* are syngenesious and each has a tuft of trichomes at the apex. The *fruit* is an *inferior capsule about 7 to 8 mm. long, obovate, with two loculi* containing about 500 minute seeds, it is inflated and dehisces by two pores in the summit. The pericarp is membranous and has ten ribs which are connected by numerous horizontal veinlets, the sepals are persistent. The *seeds* are about 0 6 to 0 7 mm. long and 0 25 to 0·3 mm.

wide; they are red-brown and covered with fine elongated-polygonal reticulations, see Fig. 115.

Histology. The upper internodes of the stem have six rounded angles two to five of which may carry winged outgrowths of the cortex; the

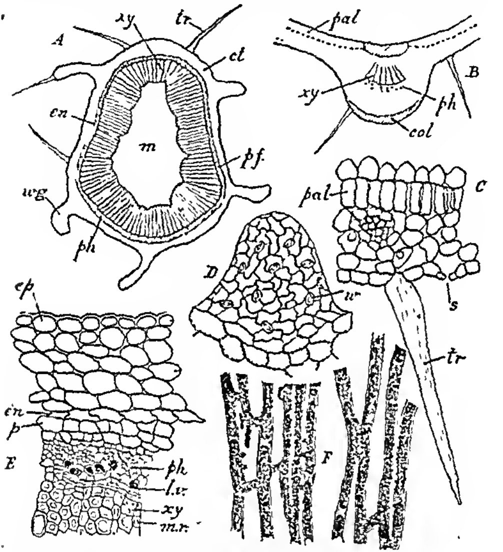

FIG. 116. *Lobelia inflata*. *A*, diagrammatic transverse section of the stem × 20. *B*, diagrammatic transverse section of the leaf × 40. *C*, transverse section of the lamina × 200. *D*, upper surface of a tooth of the leaf-margin with water-pores, *w*. *E*, transverse section of the outer part of the stem × 150. *F*, laticiferous vessels, isolated by caustic potash × 200. *col*, collenchyma; *ct*, cortex; *en*, endodermis; *ep*, epidermis; *l.v.*, laticiferous vessel; *m*, pith; *m.r.*, medullary ray; *p*, pericycle; *pal*, palisade; *p.f.*, pericyclic fibre; *ph*, phloem; *s*, stoma; *tr*, trichome; *w*, water-pore; *wg*, wing; *xy*, xylem. (*E* and *F* after Greenish.)

pith is large, occupying about one-third to one-half of the diameter of the stem, consists of lignified, thin-walled parenchyma with simple pits. The epidermis consists of axially elongated cells, it bears trichomes similar to those of the leaves, but reaching a length of 1,200μ, and has stomata oriented parallel to the axis. The cortex is 100 to 200μ wide and consists

of round-celled parenchyma; the endodermis is well marked, consisting of rather large cells with an obvious casparian strip. The phloem is about 50μ wide and contains a cylindrical network of laticiferous vessels. The *leaves* are dorsiventral, having a palisade of one layer of rather wide, cylindrical cells. All cells of the mesophyll contain minute droplets of oil and in some leaves numerous small rod-shaped crystals are present in many of the cells. The upper epidermis is papillose with nearly straight, beaded anticlinal walls and a striated cuticle; stomata are absent except on the teeth, each of which has eight to twelve water-pores, some of them being on the edge. The laticiferous tissue is well developed in the phloem of the meristele in the midrib. The trichomes are scanty on the upper surface and more numerous on the lower; they are unicellular, occasionally

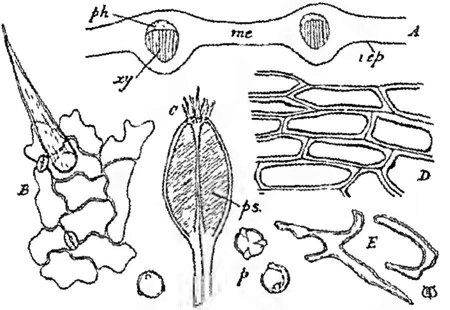

FIG 117. *Lobelia inflata* A, diagrammatic transverse section of the pericarp. B, inner epidermis of the pericarp. C, stamen × 20. D, epidermis of the seed × 200. E, sclereids from below a vein of the pericarp. *i ep*, inner epidermis, *me*, mesophyll, *p*, pollen grains × 200; *ph*, phloem; *p s.*, pollen-sac; *xy*, xylem.

bicellular and uniseriate, conical, about 300 to 600μ long and 50 to 60μ wide at the base, with lignified walls and a longitudinally striated cuticle. The *flowers* have a corolla with a papillose upper epidermis and anthocyanin pigment in the cell sap; the stamens have an apical tuft of narrow cylindrical trichomes, about 300μ long, with rounded apices; the pollen grains are sub-spherical with a faintly warty outer surface and three pores, they are about 20 to 30μ in diameter. The pericarp of the *fruit* has well-developed irregularly shaped lignified idioblasts in the parenchyma, especially beneath the veins and in the dissepiment. The *seeds* have a characteristic epidermis of elongated-polygonal, tabular cells, about 100μ by 25μ, with lignified and thickened anticlinal walls.

The drug has a somewhat irritant odour, and, when chewed, an unpleasant, acrid, burning taste.

It is said that the plants are sometimes allowed to mature their

seeds and are then thrashed, the seeds being sold separately, whilst the herb is pressed into packets. This would account for the absence of the flowers from some specimens of the drug, and for the presence of numerous capsules but comparatively few ripe seeds.

Constituents. Five crystalline alkaloids have been isolated from lobelia. The chief of these, lobeline ($C_{22}H_{27}O_2N$), forms colourless crystals, m.p. 130°–131°. Lobelidine ($C_{22}H_{25}O_2N$) has been obtained in prismatic crystals, m.p. 106°. Lobelanine ($C_{22}H_{25}O_2N$) crystallises in rosettes of needles m.p. 99° and is converted by reduction into lobelanidine ($C_{22}H_{29}O_2N$) which crystallises in large colourless prisms m.p. 150°. Isolobelanine ($C_{22}H_{25}O_2N$) forms large crystals m.p. 120° (Wieland, Schopf and Hermsen, 1925).

Uses. Lobeline has an action closely allied to that of nicotine; it first excites the nerve-cells and then paralyses them. The drug relaxes the bronchial muscles and thus dilates the bronchioles; it is given in spasmodic asthma and in the dyspnœa of chronic bronchitis; it is expectorant and diaphoretic. Large doses produce vomiting, and may cause collapse through medullary paralysis.

CHIRETTA, Chirata, Herba Chirettæ

Sources, etc. Chiretta, *Swertia Chirāta* Hamilton, family Gentianaceæ, is [illegible] a metre, indigenous to [illegible] has long been used by the [illegible] medicine till about 1830. The entire plant is collected when the flowering is well advanced, and made into bundles about a metre long, weighing nearly a kilogramme each, which are often compressed for exportation.

Description. The stem, which attains about 6 mm. in thickness, is of a yellowish-brown or purplish-brown colour, glabrous, and slightly winged. The lower part is rounded, and exhibits, when cut longitudinally, a narrow wood enclosing a large, continuous, easily separable pith; the upper part of the stem produces in the axils of opposite leaves numerous slender, elongated, decussate branches which ramify further, bearing numerous fruits and occasional flowers.

The few leaves to be found are opposite and sessile, ovate or lanceolate in outline, acuminate, entire and glabrous. The fruits are bicarpellary, superior, ovoid and pointed capsules, unicellular with numerous seeds, which are about 0·27 to 0·54 mm. long and 0·16 to 0·45 mm. wide, irregularly ovoid and finely reticulate.

The tapering root attains about 10 cm. in length and 12 mm. in thickness at the crown, and is frequently oblique.

The drug has no marked odour, but all parts have an extremely bitter taste.

Constituents. Chiretta is said to contain two intensely bitter principles, ophelic acid and chiratin, both amorphous or indistinctly crystalline yellow substances. Tannin is absent.

Uses. This drug, which has bitter and tonic properties, is highly esteemed in India and much used as a tonic. In this country it is now but seldom prescribed, probably on account of the very disagreeable nature of its bitterness.

Adulterants. The name chiretta being applied in India to a number of bitter plants, it is not surprising that other more or less similar bitter drugs are occasionally mixed with or substituted for the official chiretta. Sometimes, too, plants that resemble true chiretta in appearance but are

much less bitter make their appearance under the name of chiretta. Among the substitutes and adulterants may be mentioned *Swertia angustifolia* Buch-Hamilton; *S. alata* Royle; *S. trichotoma* Wallich, etc.; *Andrographis paniculata* Nees, family Acanthaceæ; the root of *R*... Linn., family *Rubiaceæ*, etc. The la... intensely bitter taste are sufficien...

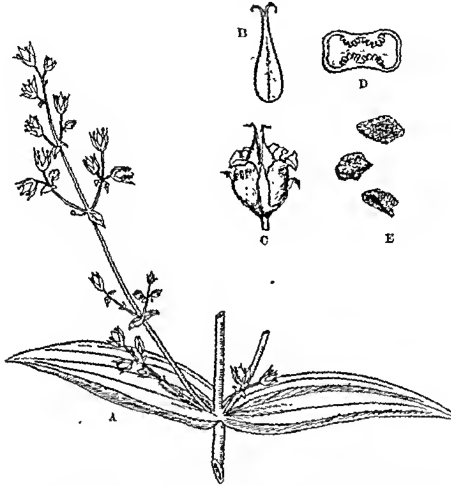

FIG. 118. Chiretta. *A*, two opposite leaves and part of the inflorescence. *B*, pistil of the flower. *C*, fruit with persistent calyx. *D*, transverse section of fruit. *E*, seeds × 20.

species of the same genus; the opposite leaves and bicarpellary, unilocular fruits, from plants belonging to families not possessing those characters.

Japanese Chiretta, derived from *S. chinensis* Franchet, is a much smaller plant; the stem varies from 10 to 35 cm in length and 1 to 2 mm. in thickness, and is brown or purplish-brown; the root is straight or only slightly oblique; it yields more alcoholic extract and is more bitter than *S. Chirata*. It contains a crystalline glucoside, swertiamarin, yielding by hydrolysis with emulsin erythrocentaurin and glucose; it also contains crystalline tasteless swertic acid (Karyone and Matsushima, 1927).

EUPHORBIA PILULIFERA. Herba Euphorbiæ .

Source, etc. The herb known in commerce as Euphorbia pilulifera is derived from *Euphorbia hirta* Linn., family Euphorbiaceæ, an annual herb indigenous to the hotter parts of India and occurring in all tropical countries. The whole of the aerial part of the plant is collected whilst flowering and fruiting, and dried. It is exported chiefly from India.

Description.
the young uppe
with short curv
The leaves are from 2 to 4 cm. long, opposite, oblong-lanceolate, shortly petiolate, minutely dentate or serrulate and unequal at the base. They are

FIG. 119. Euphorbia pilulifera. *A*, upper part of stem with leaves and axillary inflorescences, natural size. *B*, fruit × 12. *C*, base and side view of seed × 20. (From *Pharm. Journ.*)

dark green in colour, frequ
and lower surfaces are hair
or terminal cymes about 1
three-celled capsule, about
being distinctly keeled, a
transversely wrinkled seed.

Constituents. Investigations have failed to isolate any particular constituent, although it is believed to contain a poisonous glucoside.

Uses. It has been recommended for asthma, bronchitis, hay fever, whooping cough, and other affections of the respiratory organs, but has never come into general use.

BELLADONNA HERB. Folia Belladonnæ, Belladonna Leaf. Deadly Nightshade Leaves

Sources. European Belladonna herb consists of the fresh or dried leaves and flowering tops of *Atropa Belladonna* Linn., family Solanaceæ,

an herbaceous perennial growing to a height of about 2 metres and indigenous to central and southern Europe, as well as to the southern counties of England where it grows especially on chalky soils, usually on the outskirts of woodland. Belladonna is cultivated in England, on the European continent and in the United States of America. Considerable quantities of the dried drug are imported into Britain from abroad.

Cultivation and Collection. Seed is obtained either by crushing the berries, allowing to ferment for about three days and washing the seeds clean with water, or the fruits may be dried by spreading them on sieves in August or September and turning frequently during fifteen to thirty days. The dry fruits are broken between the fingers and the seeds passed through a sieve which retains the pulp. The seed may be sown in the spring in the field or it may be germinated in frames in January or February and the plants set out in the field in April. Germination is assisted by exposing the soaked seeds to temperature of about 0° C. in a refrigerator for a week (Melville, 1941). The seedlings are spaced about 45 cm apart and in the following September the first collection of drug is made by cutting off the entire tops of the plants, which are now thinned out to 1 metre apart In the second year three or four stems are thrown up from each root-stock and leaves are collected in May, when the first flowers are appearing, by cutting down the plants to about 8 cm. above the soil. Fresh stems arise and yield a second abundant crop about the middle of August; this crop is generally richest in alkaloid. In favourable seasons a third crop may be taken in October. The third year yields similar good crops, the plants now being at their best. At the end of the third year, plough up the roots, collect, wash and dry them. They are sometimes allowed to remain for a fourth year, at the end of which the roots are ploughed up. The reaping of the foliage is done with a scythe or a billhook. Farmyard manure is very successful to improve the crop and superphosphate and nitrate of potassium or sodium are useful chemical manures.

The leaves are stripped from stems over 5 mm in diameter and together with the smaller stems with their attached leaves and flowers are dried at about 40° to 50° C in a dark heated drying-shed, the operation being conducted as rapidly as possible. In about forty-eight hours the drug is dry and should have a good green colour. On the European continent the leaves are often dried in well-ventilated barns by hanging the plants in bunches or spreading them on hurdles.

Plants attacked by the fungus *Phytophthora Belladonnæ* should be dug up and burned A small flea-beetle, *Epithrix atropæ*, also attacks the leaves eating them away till little more than the veins is left. This pest is best controlled by taking two or three crops each year as described above, when the plants will be kept clear of beetles which attack chiefly the older leaves.

Description. The drug consists of the flattened or curled and twisted and often much broken leafy branches bearing flowers and young fruits, stems which, when dry, exceed 5 mm. in diameter and have leaf-scars covered with a brown absciss layer of cork should be excluded from the drug. The *stem axis* is green to purplish-green, somewhat flattened with one or two deep grooves due to shrinkage while drying, it bears leaf-scars in an alternate arrangement and has a few trichomes which are most evident at the nodes and on the most slender stems The larger pieces, 5 mm. or more in diameter, have numerous small brownish prominences. The centre of the stem is occupied by a large hollow, surrounded by the scanty remains of the

pith, outside which is a narrow cylinder of xylem and a still narrower one of bark. The younger stems show at each node a pair of leaves, one large and one small, and also a flower or young fruit. This arrangement is due to the cymose branching of the axis to form a cincinnus and to the adnation of each bract to its axillary branch up to the point where the next branches arise.

The *leaves* are ovate to broadly ovate, about 6 to 10 cm., sometimes up to 20 cm. long, dull yellowish-green; the lamina is simple, entire, nearly glabrous, with an entire margin, an acuminate apex, an acute

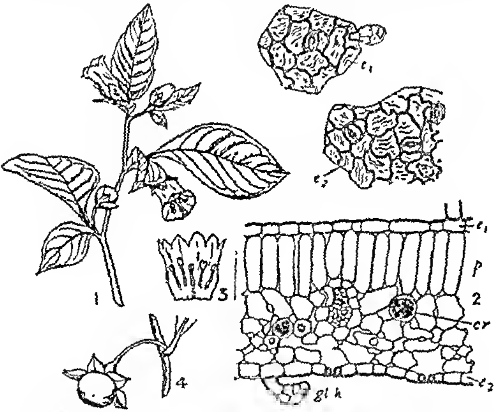

FIG. 120. Belladonna. 1. Habit sketch of a flowering top (partly after Greenish) × $\frac{1}{2}$. 2. Transverse section of lamina of leaf × 160 (after B. Gram). 3. Corolla of flower, opened to show stamens, × $\frac{1}{2}$. 4. Young fruit × $\frac{1}{2}$. *cr*, idioblast with microsphenoidal crystals; e_1, upper epidermis; e_2, lower epidermis, *gl. h.*, glandular trichome, *p*, palisade.

base where the lamina is decurrent; the secondary veins leave the midrib at an angle of about 60 degrees and curve upwards as they approach the margin, near which they anastomose by a series of arches; the petiole is short. The leaves are thin and brittle and when broken across, small white points are evid[illegible] edge due to the presence of cells filled with [illegible] ich also give rise to num[illegible] lamina.

Th[illegible] long and 1·0 to 1·4 cm. wide, with a curv[illegible] and show the typical solanaceous structure. The corolla is campanulate and livid purple when fresh, but brownish when dry. The young *fruits* are sub-spherical berries, green when fresh,

about 3 to 10 mm. in diameter and surrounded by the inferior, persistent and somewhat enlarged calyx with acute leafy lobes; the fruits darken on drying. The ripe fruits are very succulent, sub-spherical berries, purplish-black and about 2 cm. in diameter. The berry is bilocular and contains numerous seeds attached to an axile placenta and embedded in a pulpy mass.

The *seeds* are yellowish-brown, about 1·7 × 1·5 × 1·0 mm., oblong-reniform with a slight point at one end, where the hilum and micropyle are situated. The surface has polygonal reticulations, with almost straight edges and about 0·1 mm. in diameter; immature seeds may have wavy edges to the reticulations.

Histology. *Stem*; the epidermal cells are slightly elongated axially and the trichomes and stomata, which are not numerous, resemble those of the leaf; the cuticle is longitudinally striated; the cortex consists of rounded

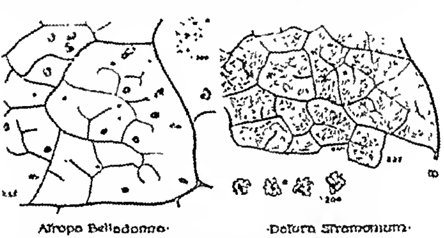

FIG. 121. Diagrams showing vein-islets and distribution of crystals in leaves of belladonna and of stramonium. Both × 25.

parenchyma and has scattered idioblasts with sandy microsphenoidal calcium oxalate, the endodermis contains starch. The pericycle consists of one or two layers of parenchyma and has a few pericyclic fibres either isolated or in small groups of two to four. The phloem is narrow and the xylem has large reticulate vessels and abundant fibres. Perimedullary phloem of supernumerary strands is present in a pith of rounded cells amongst which are idioblasts similar to those of the cortex. *Leaf*: the epidermis consists of tabular cells having a striated cuticle, sinuous to nearly straight anticlinal walls and bearing simple four- to five-celled uniseriate conical trichomes with a smooth cuticle, 150 to 250 to 300μ long and 15 to 40 to 70μ wide at the base, and glandular trichomes, some short and clavate, 70 to 100μ long and others longer uniseriate with a spherical unicellular head. Stomata are cruciferous and few, about 8 to 10 to 18 per square millimetre, on the upper surface, but numerous, about 150 per square millimetre, on the lower. The stomatal index for the lower surface is 19·5 to 21·6 to 24. (Rowson, 1943.) The mesophyll has a single layer of palisade and in the spongy parenchyma are occasional rounded idioblasts containing sandy microsphenoidal crystals of calcium oxalate, individual crystals being 1·5 to 7μ across. The palisade ratio is six to eight, rarely up to ten, and never smaller than five. The meristele of the midrib is surrounded

by endodermis containing starch and there are supernumerary groups of phloem on the upper side. *Flowers*: the petals are reddened by chloral hydrate and the inner epidermis of the corolla is papillose in the upper part and bears trichomes on the basal part where the filaments are adnate. The outer epidermis of the corolla has cells with wavy anticlinal walls and bears numerous trichomes with uniseriate stalks and either a unicellular spherical head or a row of two to four more or less globular secreting cells. The pollen grains are subspherical, 40 to 50μ in diameter, with three pores from which splits in the exine extend nearly to the poles, the exine has rows of fine pits radiating from the poles to the equator. The epidermis of the fruit consists of polygonal cells with straight anticlinal walls and has stomata near the apex and base, but almost absent elsewhere.

Varieties. *Indian Belladonna Herb* is derived from *A. acuminata* and closely resembles the European drug. The leaves are pale green, oblong-elliptical and taper at both the apex and base of the lamina; it is, however, possible to find leaves from both plants, which are indistinguishable. The flowers of *A. acuminata* have yellow, funnel-shaped corollas. The fruit is similar to that of *A. belladonna*, but is slightly conical at the apex.

Constituents. The chief constituent of the drug is the alkaloid hyoscyamine. Small amounts of hyoscine, from about 0 to 11 per cent. of the total alkaloid, are also present. Atropine is absent from samples consisting of younger leaves and generally from drug collected not later in the year than August. Drug consisting of older leaves may contain atropine to the extent of about 5 to 40 per cent. of the total alkaloid. (Rowson, 1945.) Good samples contain about 0·4 per cent. of total alkaloid, but as much as 1 per cent. has (exceptionally) been found. The alkaloid is contained in all parts of the plant; in the calices and young ovaries 0·70 per cent. has been found, in the ripe seeds 0·83 per cent., in the root 0·5 per cent., and in fresh fruit 0·12 per cent.; in the leaves it occurs in all the parenchymatous cells, but particularly in those of the lower epidermis. The volatile bases pyridine, N-methylpyrroline, N-methylpyrrolidine and a diamine are also present; they are therapeutically unimportant, but may vitiate assays of belladonna unless driven off by heat.

Belladonna leaves also contain a fluorescent substance, β-methylæsculetin (scopoletin, chrysatropic acid), and yield about 14 per cent. of ash.

Adulterations. Several leaves have been used as adulterants of belladonna; the following occur from time to time.

1. Leaves of *Phytolacca decandra* Linn., the Pokeweed, family Phyto- [illegible]

and the stomata are ranunculaceous.

2. Leaflets of *Ailanthus glandulosa* Desf., the tree of heaven, family Simarubaceæ. These are triangular ovate with a sharply acute apex; both surfaces are pubescent with whitish trichomes which are unicellular, rarely bicellular, lignified and sharply conical with longitudinal striations. The cuticle has very well-marked striations. Cluster crystals of calcium oxalate occur near the veins and the stomata are ranunculaceous, see Fig. 122.

3. Leaves of *Scopolia carniolica* Jacquin, family Solanaceæ, are rather more lanceolate and thinner than belladonna, but are so closely similar as to be indistinguishable with certainty without the microscope. They have scattered glandular trichomes like the clavate ones of belladonna but no covering trichomes; they also have cuticular striations and sandy microsphenoid as well as a few clusters of calcium oxalate; in all these features they resemble belladonna. The only reliable character to distinguish *Scopolia* leaves is the palisade ratio which is three to six and very rarely over five, whereas the figure for belladonna is five to ten. In most samples the fruits are present and are very characteristic, the fruit

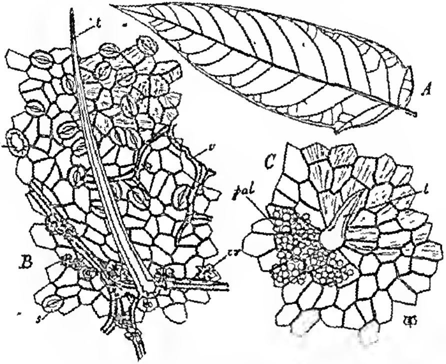

FIG 122. *Ailanthus sp.* *A*, leaflet × ½ *B*, under epidermis of leaflet *C*, upper epidermis of leaflet. *B* and *C* × 175 *c*, scar left by trichome, *cr*, cluster crystal of calcium oxalate, *pal*. palisade, *s*, stoma; *t*, trichome; *v*, vessels. See also Fig. 29, p 105.

being a sub-spherical pyxis surrounded by the papery, veined calyx. They contain hyoscyamine and scopolamine, about 0·5 per cent.

4 Leaves of *Datura Stramonium* Linn. and of *Solanum nigrum* are sometimes substituted for belladonna leaves, see pp. 286 and 288.

Uses. Belladonna acts as a local anæsthetic and anodyne, and is used externally to relieve pain. Internally, it is given to check the sweating in phthisis, as a sedative to the respiratory nerves, to relieve spasmodic cough, and in numerous other cases.

STRAMONIUM. Folia Stramonii. Thornapple Leaves

Sources. Stramonium consists of the dried leaves and flowering tops of *Datura Stramonium* Linn. and *Datura Tatula* Linn, family

Solanaceæ, plants indigenous to the shores of the Caspian Sea and believed to have spread throughout Europe about the first century A.D. *D. Stramonium* is now common throughout Europe, Asia, America and South Africa, occurring as a weed growing in waste places, at the edges of roads and on rubbish heaps in the warmer districts. It is cultivated for the production of the drug in Southern England, and in Germany, France and Hungary.

Cultivation and Collection. Both [illegible] closely similar [illegible] while [illegible] veins [illegible] rows

FIG. 123. *Datura* [illegible] *A mature* [illegible] 4. Trans-

1 metre apart, the plants being thinned out to about 60 cm. apart in the rows. Abundant farmyard manure is [illegible] be about 1 metre h[illegible] October. The firs[illegible] removing the lower leaves about July and the main collection of the upper flowering stems is made [illegible] 10 cm. long, [illegible] is dried as [illegible] a process which requires about forty-eight hours.

Description. The drug consists of [illegible]

[illegible] about 10 to 20 cm. [illegible]

with small irregular dentations on the lobes, nearly glabrous, the secondary veins are three to five on each side of the midrib, which they leave at a narrow angle of about 45 degrees and run into the acute apices of the lobes. The shrunken stems are much curved and twisted, longitudinally grooved and marked by numerous curved transverse and longitudinal wrinklings; they branch to form a dichasial cyme in which each bract is displaced by adnation to the axillary shoot up to the point where the next branches arise. Flowers and young fruits are attached by short pedicels at the forks of the stems; the flowers are about 8 cm long and 5 mm. wide with shrivelled

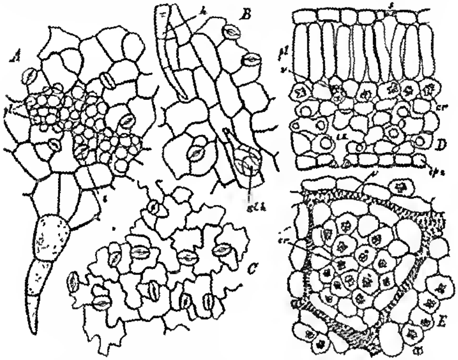

FIG 124. *Datura stramonium*. *A*, upper epidermis. *B*, upper epidermis over a vein. *C*, lower epidermis. *D*, transverse section of lamina. *E*, crystal layer in surface view. All × 150. *cr*, cluster crystal of calcium oxalate; *ep*$_2$, lower epidermis; *gl h.*, glandular trichome, *h*, covering trichome; *i.s.*, intercellular space; *pl*, palisade; *s*, stoma; *v*, vessels

tubular calyces about 3 cm. long and pale brown shrivelled corollas; the fruits are usually immature, about 5 to 10 mm long, conical and covered with bristly emergencies. The transversely cut surface of the slender stems shows a large solid pith, surrounded by a whitish xylem about 1 mm. wide and a very narrow bark.

The odour of the drug, though not strong, is disagreeable and characteristic; the taste is unpleasantly bitter.

Histology. The *stem* is similar in general structure to that of belladonna, see p. 283; the epidermal trichomes are similar to those of the leaf, but may attain a length of 800μ; many cells of the pith contain cluster crystals of calcium oxalate and a few sandy microsphenoidal crystals.

Leaves: epidermis of cells with more or less sinuous anticlinal walls and a smooth cuticle, the covering trichomes are not very numerous, those of *D. Stramonium* are conical and uniseriate with 1 to 3 to 4 cells and a length of 150 to 275 to 580μ and a breadth at the base of 30 to 60 to 95μ, the cuticle is warty; those of *D. tatula* are composed of 3 to 4 to 8 cells, up to 650μ long and 110μ wide at the base; clavate glandular trichomes, similar to those of belladonna, occur chiefly on the under surface of the veins, they have two to seven cells in the glandular head. The palisade ratio is four to seven; never less than four. The stomata are of the cruciferous type and in *D. Stramonium* there are per square millimetre about 60 to 140 on the upper and 140 to 250 on the lower surface; the corresponding figures for *D. tatula* are 93 to 175 for the upper and 155 to 331 for the lower surface. The midrib resembles that of belladonna in general structure, but has rather more hypodermal collenchyma and some cells with clusters and others with sandy microsphenoidal calcium oxalate. The *flowers* have pollen grains measuring 60 to 80μ in diameter, being much larger than those of belladonna and henbane, see Fig. 124.

Constituents. Stramonium contains the alkaloid hyoscyamine, from 0·2 to 0·7 per cent., and by cutting off the flowers this has been increased to 1·8 per cent. (Sievers, 1921). Atropine has been reported as a constituent, but is probably formed from hyoscyamine during the process of extraction; none was found in Egyptian stramonium. Daturine was the name given to the mixture of alkaloids originally extracted from the drug.

Pater (1925) found in the leaves of *D. Stramonium* 0·265 to 0·342 per cent. of total alkaloid, in the roots 0·120, in the leaves of *D. tatula* Linn., 0·318, and in the leaves of *D. inermis* Jacquin, 0·285.

The alkaloids in the leaf are localised chiefly in the epidermis, particularly the upper, and in the phloem parenchyma of the veins, the midrib containing more than the petiole, and both being much richer than the leaf. Hence the practice sometimes followed of rubbing the leaves through a coarse sieve (laminating) and rejecting the midribs and larger veins should be discontinued. The commercial laminated drug frequently contains *Xanthium* leaves (see below). The main stem contains but little alkaloid, and therefore should not be present in the drug.

Adulterations. Leaves of *Xanthium Strumarium* Linn., family Compositæ. These are pale greyish-green, rhomboid ovate, with a coarsely and irregularly serrate margin; they are rough from the presence of cystolith trichomes. The midrib shows from three to six separate bundles, the epidermal cells have straight anticlinal walls, three types of trichome are present, viz., conical, usually three-celled, uniseriate trichomes with cystoliths of calcium carbonate in the basal or two basal cells, narrow uniseriate trichomes about seven cells long, and compositous glandular trichomes. Crystals are absent.

Leaves of *Xanthium macrocarpum* DC. have also been reported.

Leaves of *Carthamus helenoides* Desf., family Compositæ. These are distinguished by the presence of three separate bundles in the midrib; large epidermal cells with straight anticlinal walls and a striated cuticle; the uniseriate covering trichomes of fifteen to sixteen cells; the compositous glandular trichomes; schizogenous secreting ducts near the veins; absence of clusters of calcium oxalate.

Leaves of *Solanum nigrum* Linn., family Solanaceæ; these are petiolate, ovate, with a coarsely toothed or wavy margin; they closely resemble small stramonium leaves. They contain no cluster crystals of calcium

oxalate, but the form of the epidermal cells and of the trichomes is similar to that of stramonium. The most diagnostic character is the palisade ratio, which is two to four.

Leaves of *Chenopodium hybridum* Linn., family Chenopodiaceæ, these have a general external resemblance to small leaves of stramonium; they contain abundant cluster crystals of calcium oxalate; the trichomes are somewhat rare but are characteristic, having a slender pedicel and a large bladdery water-storing terminal cell.

Leaves of *Hyoscyamus niger* Linn., family Solanaceæ are sometimes substituted for stramonium when the latter is scarce.

Uses Stramonium leaves resemble belladonna in their action; they are, however, almost exclusively used in the treatment of spasmodic affections of the respiratory organs.

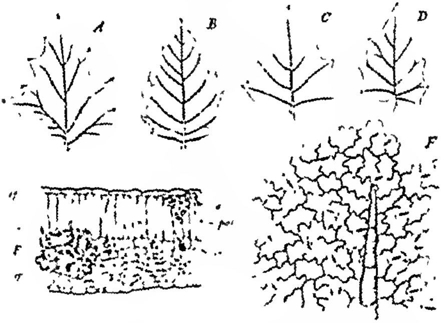

FIG. 125. Leaves of *Datura* spp. *A*, *D. stramonium*; *B*, *D. innoxia*; *C*, *D. fastuosa*; *D*, *D. metel*. All × ½. *E*, *D. fastuosa*, transverse section of lamina, × 100; *F*, *D. metel*, lower epidermis, × 100; note the collapsed and sunken stomata. *a*, irregular crystalline masses; *ep*, upper epidermis; *ep*, lower epidermis; *cr*, cluster of calcium oxalate; *pal*, palisade. (All after Timmermann.)

DATURA HERB. Herba Daturæ, Folia Daturæ, Datura leaves

Sources. Datura herb or leaves consists of the dried leaves and flowering tops of *Datura innoxia* Miller and *D. metel* Linn., family Solanaceæ. Both are annual plants and grow freely in India, to which country *D. metel* is indigenous.

Description. The leaves of *D. innoxia* Miller are petiolate, ovate or somewhat ovate, about 12 cm long and 7 cm wide, but may reach a length of 25 cm and a width of 15 cm; the margin is entire or may show a few small teeth; the apex is acute; both surfaces are densely pubescent. There are about seven to ten secondary veins on either side of the midrib, which anastomose by arches at about 1 to 3 mm from the margin. The

dichasially branched stems are pubescent and much twisted and unripe fruits are often present in the forks.

The leaves of *D. metel* Linn., are petiolate, ovate, usually unequal at the base, about 8 to 13 cm. long and 7 cm. broad; the apex is acute and the lamina is nearly glabrous and usually has three or four coarse teeth on each side and there are four to six secondary veins on each side of the

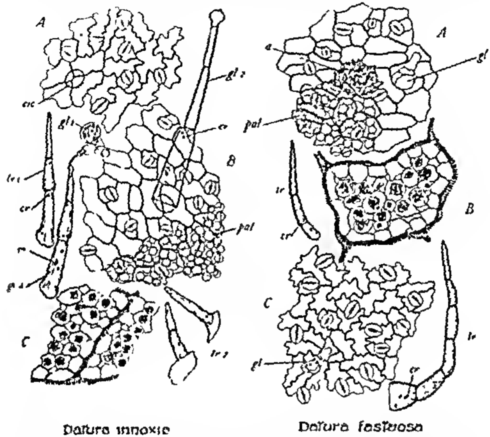

FIG. 126. *Datura innoxia* Miller, surface preparations of the leaf. *A*, lower epidermis. *B*, upper epidermis. *C*, crystal layer and vessels. *cic*, cicatrix; *cr*, calcium oxalate crystals; *gl*, short-stalked glandular trich[illegible] trichome; gl_1, warty and wrin[illegible] *pal*, palisade; tr_1, warty and [illegible] [wri]nkled covering trichomes. All × [illegible]

Datura fastuosa Linn., surface preparations of the leaf. *A*, upper epidermis. *B*, crystal layer and vessels. *C*, lower epidermis. *a*, crystalline mass of unknown identity; *cr*, calcium oxalate crystals; *gl*, glandular trichome; *pal*, palisade; *tr*, covering trichome. All × 100. (After Timmerman.)

[illegible]

The leaves of *D. innoxia* possess very numerous trichomes, most of which are slightly warty, long-stalked, glandular trichomes with a small unicellular spherical secreting head; a small number of warty uniseriate conical covering trichomes, the basal cell of which is never more than 60μ wide at the base; also a few clavate glandular trichomes similar to

those of stramonium. The numbers of stomata, which are of the cruciferous type, on upper and lower surfaces are nearly equal, 90 to 175 per square millimetre on the upper and 100 to 225 ...

du ...
lar ...
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mil ... 140 to 250 on the lower
sur

Constituents. Datura leaves contain about 0·5 per cent. of alkaloid, chiefly scopolamine (hyoscine) with traces of hyoscyamine and atropine, and serve as a commercial source of scopolamine.

HENBANE. Folia Hyoscyami. Hyoscyamus

Sources. Henbane consists of the dried leaves and flowering tops of *Hyoscyamus niger* Linn., family Solanaceæ, a plant which occurs throughout Europe and as far east as Persia and India. It is occasionally found in southern England growing on waste ground, such as hedge-banks, roadsides and commons. It is cultivated in south-eastern England, in Thuringia and northern Bavaria in Germany and in Russia and Hungary.

Cultivation and Collection. Seed is sown in the field in June or July in rows about 75 cm. apart and are thinned out till the plants ... 60 cm. apart in the rows ... leaves are colle... In the followin... a large plant, about 1 metre ... four main stems which ... helically coiled racemes ...

... *Hyoscyamus niger* produces more slender, single-... plants, which yield a drug which sometimes appears on the market.

Description. Commercial henbane consists of matted leaves or leaves and flowering tops including stem, which, when dry, does not exceed about 5 mm. in diameter. The ... s a pale greyish-green colour and is ... Specimens consisting of leaves or ...

First Bie... These leaves are ovate-lanceolate, often more or less broken and crumpled, about 20 to 30 cm. long and 7 to 10 cm. wide with a broad, flat petiole about 5 cm. long ... coarsely dentate to ...

... secondary veins ... viscid glandular ... veins.

... the more slender ... together with leaves and inflorescences. ... stems are hollow, light green, covered with a

tangled mass of whitish viscid glandular trichomes, with one or two longitudinal furrows due to shrinkage, alternate leaf-scars and two lines running from each scar along the internode below it; the transversely cut surface shows a large central hollow, surrounded by a band of radiate whitish xylem about 1 mm. wide, which is encircled by a narrow greenish bark. The *leaves* are sessile, oblong-ovate, crumpled and broken, about 5 to 20 cm. long and 3 to 8 cm. wide, with two to five coarse teeth or lobes on each side, the base is cordate, the broad flat midrib has four or five secondary veins leaving it almost at right angles on each side, pinnately arranged and terminating in the apices

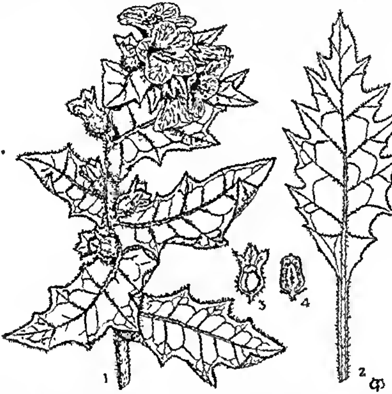


FIG. 127. *Hyoscyamus niger* L. 1. Flowering top of a biennial plant. 2. Petiolate leaf from the radical rosette of the first year's growth. 3. Pyxis enveloped by persistent calyx (front half removed). 4. Vertical section of fruit (pyxis).

of the lobes or teeth. The surface is viscid-downy especially on the midrib and main veins. The *flowers* are crowded together and have short pedicels about 4 mm. long; they are about 20 mm. long, the calyx is urceolate with five lobes, each with an apical spine, the corolla is funnel-shaped with five slightly unequal, rounded lobes, yellow with purple veins. The *fruits* are often present; each is a small ovoid-oblong pyxis about 15 mm. long, bilocular with numerous fawn-coloured to brown seeds. The *seeds* are brownish-grey, flattened, reniform-quadrangular, about 1·5 to 1·75 mm. long, 1 to 1·2 mm. wide and 0·5 to 0·7 mm. thick. The testa is marked by wavy-walled reticulations each about 0·1 mm. in diameter. The seed contains a coiled embryo embedded in an oily endosperm. The seeds have no odour and only a slightly bitter taste, see Fig. 127.

Annual Henbane is mostly imported drug of poor quality; its characters are similar to those of the biennial plant, but the stems are more slender and the leaves smaller, the whole being less viscid-hairy.

Henbane has a strong, unpleasant odour and a bitter taste.

Histology. The *stem* has a structure resembling that of the stem of belladonna; the pith, excepting in the smallest branches, having a large central hollow and containing in its periphery a network of supernumerary perimedullary phloem bundles as in belladonna. Some cells of the pith contain tetragonal calcium oxalate either in prisms or clusters of few components or microsphenoidal sandy crystals. The epidermal trichomes resemble those of the leaves. The *leaf* has an epidermis with a smooth cuticle and slightly sinuous anticlinal walls; the stomata are of the cruciferous type, about 125 per square millimetre in the upper and rather more numerous in the lower epidermis; it bears uniseriate two- to four-celled, conical covering trichomes about 100 to 300μ long, also glandular trichomes, about 100 to 500μ long, with a uniseriate stalk of two to six cells and an ovoid multicellular glandular head and some clavate glandular

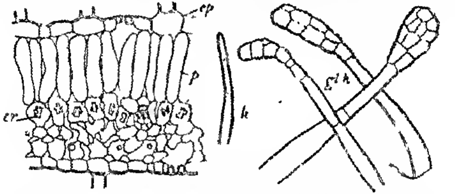


FIG. 128 Henbane leaf Transverse section, with hairs; cr, crystals of calcium oxalate, ep, epidermis; gl h, glandular hairs, h, simple hair; p, palisade × 160. (After Bille Gram.). See also Fig. 29, p. 105.

trichomes similar to those of belladonna. The mesophyll is usually dorsiventral with a palisade of one layer of cells, but occasionally the mesophyll is isobilateral or undifferentiated; a crystal layer is present beneath the palisade, the cells containing either large tetragonal prisms or clusters of few components or, near the veins, microsphenoidal sandy crystals The midrib has a meristele surrounded by a starch-bearing endodermis and showing in transverse section a long narrow arc of radiate xylem, beneath which is a narrow band of phloem, above the xylem, in the parenchyma, are several small groups of supernumerary phloem; in the cortical region are cells with crystals as in the pith of the stem. *Flower* has a corolla with yellow plastids in the mesophyll and, near the veins, cells containing purple anthocyanin. The pollen-grains are sub-spherical, about 45 to 55μ in diameter, with three pores and the exine marked with numerous fine irregularly arranged pits. *Seeds*: The epidermis of the testa is formed of cells, about 100 to 150μ in diameter, with brown, wavy, thickened and lignified anticlinal walls; the outer walls are thin and concave while the inner periclinal walls are lignified and heavily thickened.

Constituents. Henbane contains hyoscyamine and traces of scopolamine (hyoscine); atropine has been reported, but its presence is

doubtful. The total alkaloid present is about 0·045 to 0·14, occasionally up to 0·2 per cent. Annual henbane contains only about 0·03 per cent. of total alkaloid. The ash varies from 8 to 12 per cent., commercial samples often yield a larger amount, up to 22 per cent., owing to the presence of earthy matter adhering to the clammy leaves. The earthy matter is limited by prescribing a maximum for acid-insoluble ash, which should not exceed 12 per cent.

Henbane seeds contain about 0·05 per cent. (Ransom, 1891) of total alkaloid, consisting of hyoscyamine and scopolamine. In addition the seed contains 20 per cent. of fixed oil.

Uses. Henbane is used as a cerebral and spinal sedative; it does not give rise to the excitation caused by belladonna and is therefore used in insomnia when opium cannot be given; it also relieves the griping caused by drastic purgatives.

The *seeds* have been used as a source of the alkaloid scopolamine. They have a similar action to the leaves, but are rarely used. Thrown upon hot coals they give off a vapour which is a domestic remedy for toothache, being allowed to enter the mouth for this purpose.

Substitutes and Adulterations. *Hyoscyamus albus* Linn., grows in the Mediterranean Basin and in India; it is a perennial and is cultivated in the south of France and in Cyprus; continental henbane may consist chiefly of this plant. The stem leaves are rather small, about 5 to 10 cm. [illegible] 7 to 8 cm. long and the [illegible] trichomes are rathe[illegible] glandular ones have a small unicellular sub-spherical head.

Leaves of Dandelion, *Taraxacum officinale* Wiggers, family Compositæ, have been substituted for leaves of henbane. Dandelion leaves are [illegible] long and 2 to 6 cm. [illegible] veins leave it at a wide angle, approximating 90 degrees; the leaves vary much in size and are nearly glabrous.

The vascular bundles of the meristele in the midrib are separate and often about ten in number, arranged in an ellipse as seen in a transverse section. Stomata are present in both epi[illegible] cells with slightly sinuous anticlinal wal[illegible] indefinite palisade of two layers of cells [illegible] few trichomes are uniseriate and may be simple, ending in a spathulate cell or rarely glandular, ending in a spherical secreting cell; near the base are a very few pluricellular emergencies. See Fig. 29, p. 105.

EGYPTIAN HENBANE. Hyoscyamus Muticus

Sources. *Egyptian henbane consists of the dried leaves, smaller stems* and flowering tops of *Hyoscyamus muticus* Linn., family Solanaceæ, an herbaceous perennial growing in the sandy districts of Egypt.

Description. The *stems* are yellowish, terete, hollow and longitudinally grooved as a result of drying; the dried *leaves* are pale green and brittle, up to 15 cm. long, ovate-lanceolate to lanceolate; the radical ones are petiolate and the lamina has *two or three* large teeth on each side and an acuminate apex; the upper leaves are sessile, more lanceolate and have [illegible] the venation and surface characters resemble those of [illegible] stems; each flower [illegible] 4 cm. long, with ten

longitudinal ribs and five short triangular teeth; the corolla is deep purple with yellowish streaks and five unequal lobes, projecting beyond the calyx; the epipetalous stamens have hairy purple filaments and oblong, yellow anthers. The *fruit* is a bilocular cylindrical pyxis about 1·5 cm long and 6 mm. wide; it is enclosed by the persistent calyx. The *seeds*, when present, closely resemble those of henbane and are about 1 mm. in diameter.

Histology. The leaves resemble those of henbane in general structure. The chief differences are that the cuticle is often striated; the trichomes are usually branched, each branch terminating in a unicellular, subspherical gland; the lamina is iso-bilateral, the palisade of the under side being composed of shorter cells than that of the upper.

Constituents. Egyptian henbane contains 0·7 to 1·5 per cent. of total alkaloid, most of which is hyoscyamine.

Uses. Similar to those of henbane and as a source of the alkaloid *hyoscyamine*.

ANIMALS

Of entire animal organisms used as remedial agents, leeches belong to the class of vermes or worms and cochineal, cantharides and mylabris belong to the class of insects; they are all invertebrates.

LEECH. Hirudo

Sources. Leeches are living annelid worms, three kinds being used. The species *Hirudo medicinalis* Linn. occurs in two varieties, the speckled or German leech and the green or Hungarian leech; *this leech is grown on* special leech farms in Germany, near Hanover. The third medicinal leech is *Hirudo quinquestriata* Schmarda, found in Australia. They are aquatic annelid worms belonging to the family Hirudinidæ.

Cultivation. Leeches are reared in ponds, usually oblong in form and about 1 metre deep; the bottom is covered with clay and the banks are made of peat or clay The leeches lay their eggs or cocoons in the banks from June onwards until the weather becomes chilly. The young leeches require about five to seven years to come to maturity and they live for twelve to fifteen years. Twice yearly they are fed with fresh blood enclosed in stout linen bags, which are suspended in the water. The leeches are exported in barrels, the head being made of stout canvas so as to admit air; each barrel holds about 2,000 leeches.

Description. Leeches are continually contracting and extending their bodies and move about with a looping motion or they swim fully extended, when they are about 10 to 12 cm long and 0·8 to 1·0 cm. wide, with an undulating movement. When contracted, leeches are about 3 to 3·5 cm. long and 1·5 to 1·8 cm wide The body is formed of ring-shaped segments, of which there are from 90 to 100 and it tapers towards its ends each of which has a disc-shaped sucker. The green leech is olive-green with six longitudinal stripes on the dorsal surface, the speckled leech is similar, but the ventral surface is greenish-yellow with black spots. The Australian leech *is yellowish brown above with five longitudinal stripes*, ventrally it is greenish-yellow, see Fig. 129

The anterior disc, which is smaller than the posterior, contains three jaws radiating from a common centre; each jaw is furnished with a number of minute teeth, and resembles a portion of a circular saw. The animal attaches itself by means of its anterior sucker to the skin, which is thereby slightly raised; the three jaws, by a saw-like movement, produce

three slits which unite to form the characteristic triradiate cut, and the leech gorges itself with blood; it then relinquishes its hold, and drops from the skin. The blood which it has drawn is about 4 to 8 mils, and is so slowly digested that a single meal will last for several months.

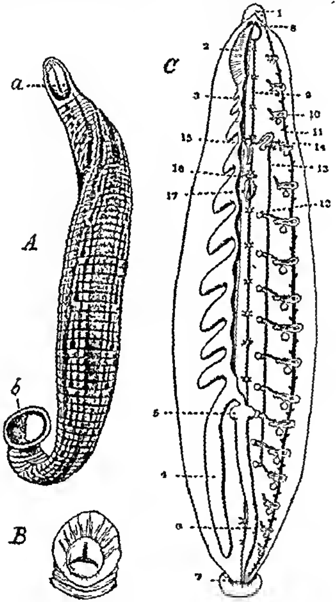


Fig. 129. Leech, *Hirudo medicinalis*. *A*, external features. *a*, anterior sucker; *b*, posterior sucker. *B*, mouth and anterior sucker. *C*, internal organs. 1, head with eye-spots; 2, muscular pharynx; 3 and 4, first and eleventh diverticula of crop; 5, stomach; 7, anus; 9, ventral nerve cord. (After Shipley.)

Constituents. The salivary glands of leeches secrete a substance, hirudin, which enters the cut made by its jaws when applied to the skin. Hirudin retards the coagulation of blood which will, therefore, continue to flow from the wound after removal of the leech.

Storage. Leeches are stored in earthenware pans half-filled with rain-water and having on the bottom a layer of fine gravel or coarse sand

with a few lumps of wood charcoal. The vessel should be covered with muslin and kept in the shade at a temperature between 10° and 20° C. In very hot weather the water must be changed every day, at other times once a week or in winter once a month. The leeches change their skins periodically and the layer of gravel assists them in the process.

Uses. Leeches are used to reduce inflammation by withdrawing blood. Hirudin, extracted from leeches, has been suggested for use in thrombosis and other conditions in which the blood shows a disposition to clot too readily.

INSECTS as a class belong to a larger group of invertebrate animals, all of which have jointed legs and are named the Arthropoda. Crustaceans, spiders and mites all belong to the arthropoda. Insects are characterised by certain features of life-history and of structure. At different stages in its existence a typical insect is so different in appearance that the stages would be regarded as distinct creatures unless one observed the passage of one into another. This phenomenon is termed *metamorphosis* and the insect shows four stages, viz., egg, larva or grub, pupa or chrysalis, and imago or perfect winged insect. The body of an insect is built up of segments, each surrounded externally by a ring of chitin, which itself is divisible into a dorsal half, termed a tergum, and a ventral half termed a sternum. Each chitinous ring is connected with its neighbours by a flexible region, which gives mobility to the entire body. The muscles are attached to the inner surface of the chitinous covering or *exoskeleton*. The body of most insects exhibits three distinct parts separated by deep constrictions, a character from which the name insect is derived (Latin *in* into and *seco* I cut). The three regions thus marked out are the head, the thorax and the abdomen. The *head* of an insect, in addition to the mouth parts, bears one pair of antennæ and two large compound eyes, each composed of a number of lenses, about 1,000 to 4,000 usually. The *thorax* consists of three segments, the anterior one being the prothothorax, which is prominent in most beetles. Appendages are attached to these segments, viz., three pairs of legs and two pairs of wings. The last general feature, which may be noted, is the provision for *respiration*. Air is carried about the body by a system of tubes named tracheæ. These tubes are prevented from collapsing by the presence within them of a fine spiral thread of chitin. The finer tubes amongst the muscles and in the appendages join to form larger tubes, which eventually open at points on the sides of the segments. Through these openings, named *spiracles*, air enters and is carried by the tracheæ to all parts of the insect's body.

The *legs* of an insect are divided into joints; that next the thorax is the *coxa* or haunch, this is connected to the large *femur* or thigh by a small joint, the *trochanter*; next to the thigh is the *tibia* or shin, and the leg terminates in a *tarsus* or foot, composed of four or five small joints with claws, usually two, at its extremity.

The large sub-divisions of insects are distinguished by the characters of the wings and are named accordingly. The beetles, to which cantharides belong, have hard forewings each named an elytron, which act as protecting cases for the under wings. Hence the beetles are named *Coleoptera*, from Greek *coleos*, a sheath, and *pteron*, a wing.

The bees have membranous wings and are classed as *Hymenoptera*, Greek *hymen*, a membrane, and *pteron*, a wing. The cochineal insect belongs to the *Hemiptera*, Greek *hemi*, half, and *pteron*, a wing, a family in which many of the insects have four wings in the male, but none in the female.

CANTHARIDES. Spanish Flies, Cantharis, Blistering Beetle

Sources. Cantharides are the dried beetles, *Cantharis vesicatoria* Latreille, family Meloidæ; they are widely distributed over southern Europe.

Cantharides are collected in southern Russia, Galicia, Roumania, and also to a much smaller extent in Italy and Spain.

Collection and Preparation. Cantharides are gregarious insects and live chiefly on such trees as ash, olive, privet and elder; their presence in large numbers becomes evident by a strong unpleasant odour. Collection is made chiefly in June and July, the time chosen being early morning when the air is moist and the insects are torpid and inactive. The collectors cover their faces by cloths and protect their hands with gloves; large cloths are spread under the trees and bushes which are vigorously shaken or beaten with long poles. The beetles are transferred to suitable containers, such as sieves, and are exposed to poisonous vapours such as acetic acid, chloroform, ammonia, carbon disulphide, or fumes from a stove. They are finally carefully dried at a temperature not over 40° C.

Description. The beetles are about 12 to 20 mm. long and 3 to 6 mm. wide, shining-green or bronze-green; the head is trapezoid with a median groove in the vertex; the eyes are small, black and situated just above the point of insertion of the antennæ, which are filiform with eleven joints, the second joint being small and sub-globular, while the third is a little longer than the fourth, but never twice as long. The fore and middle pairs of legs have tarsi with five joints, while the hind pair have tarsi with four joints; each foot or tarsus terminates in two pairs of claws, the outer ones robust and the inner ones delicate. The prothorax is visible dorsally behind the head; the remainder of the thorax, as well as the abdomen, excepting its extreme hinder end, are covered by the two elytra, which meet in a straight median line. The elytra are almost glabrous and are together rather wider than the prothorax. The second pair of wings, or underwings, are thin, brown and membranous and are folded beneath the elytra.

Histology. The elytron or wing case owes its green colour to interference [illegible]

has t [illegible] nce of a close arrangement of hexagonal areas, to I [illegible] he margins of which are finely toothed so that the [illegible] ry fine regular structure capable of producing [illegible] light in the same way as an interference grating. [illegible] rface view as a brown circular area, about 7μ in [illegible] do [illegible] le concentric ring making a total diameter [illegible] o exhibits hexagonal areas similar to [illegible]

those of the upper lamella Pieces of the elytra are therefore very charact... the contents of the body consists of ... striated muscle fibres, which form a ... made from cantharides. Pieces of the exoskeleton with characteristic hairs, fragments of legs and of the membranous wings may be easily found. Pieces of the antennæ, of the compound eyes with their hexagonal facets, each about 20μ in diameter, and of the mouth parts may be found by careful search, but are not numerous.

Constituents. Cantharides ... ite crystalline body, ... n cold water and only ... ethyl acetate, chloro- ... tone. With caustic alkalies (potassium or sodium

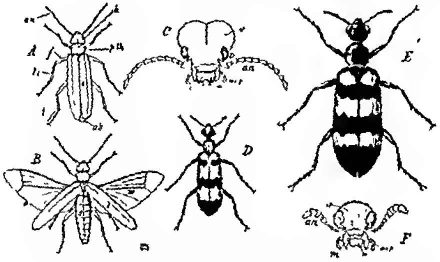


FIG 130 Cantharis and Mylabris. *A*, *Cantharis vesicatoria*, wings closed, × 1. *B*, the same, elytra raised, membranous wings expanded as in flight, × 1. *C*, the same, front of head, × 3. *D*, *Mylabris cichorii* × 1. *E*, *Mylabris sidæ* × 1 *F*, *Mylabris cichorii*, head, × 3 *a*, abdomen; *ab*, projecting tip of abdomen; *an*, antenna; *e*, elytron; *f*, femur; *h*, head; *m*, mandible; *o*, eye; *p.th*, prothorax; *t*, tarsus; *ti*, tibia; *w*, membranous hind wing

hydroxide) it unites to form soluble salts and ... evidence to show that in the beetles it exist ... din, partly in the ... insect are the ... m 0·5 to 0 8

... 12 per cent.

... arides are very prone to attack by mites, beetles and moth; they should be carefully dried and stored in well closed boxes or bottles containing a small amount of carb... lphide. The presence of moisture leads to ... idin by fermentation ...

Uses ... properties; given ... rritant poison.

MYLABRIS. Chinese Blistering Beetle, Chinese Cantharides

Sources. The species of *Mylabris* which occur in commerce as dried beetles are *Mylabris sidæ* Fabr. (= *M. phalerata* Pall.) and *M. cichorii* Linn. from China and parts of India; *M. pustulata* Thunb. from India; and less frequently *M. lunata* Pall. and *M. bifasciata* Oliv. from South Africa. These beetles belong to the family Meloidæ of the order Coleoptera.

Description. The genus *Mylabris* is characterised by the presence of a sub-globular head, a black exoskeleton and a few—usually three—brightly coloured bands, which may be yellow, orange or red upon the black elytra. A very constant feature is the presence of a single tooth just behind the tip of the right mandible so that the two mandibles are dissimilar. The antennæ are black, clavate and arcuate, with eleven joints.

M. sidæ is about 15 to 30 mm. long and 5 to 10 mm. wide; each elytron has a large orange-yellow spot at its base where it joins the thorax and also two wide transverse orange-yellow bands. Both bands and the black background have stiff black hairs, most of which are rubbed off in the commercial drug.

M. cichorii is about 12 to 20 mm. long and 3 to 6 mm. wide. The bands of the elytra resemble those of *M. sidæ*, but are more yellow and the basal one often joins the middle band along the inner margin of each elytron. Yellow hairs occur upon the bands and black hairs on the black background.

M. pustulata is about 28 mm. long and 10 mm. wide and generally resembles *M. sidæ*, but the coloured bands are bright red.

Constituents. *M. sidæ* and *M. cichorii* contain from 1 to 1·2 per cent. of cantharidin; *M. pustulata* contains up to 2·3 per cent. of cantharidin. All these beetles also contain fat and an odorous principle. The moisture present is about 8 to 11 per cent. and the ash about 5 to 9 per cent.

Uses. Mylabris is used for the same purposes as cantharides; in Britain chiefly as a source of cantharidin.

Note. Mexican cantharides is a name applied to a blistering beetle, *Cantharis quadrimaculatus* found in Mexico and also to insects, more properly known as Mexican flies, belonging to the family Rhynchota, viz., *Notonecta undulata* Say and *Corixa mercenaria* Say, which are largely used as an appetising addition to poultry food.

COCHINEAL. Coccus, Coccus Cacti

Sources. Cochineal consists of dried full-grown, fecundated female insects belonging to the species *Dactylopius coccus* Costa, family Coccidæ, order Hemiptera. The insects are indigenous to Central America and Mexico, but the drug now comes chiefly from the Canary Islands where the insects are reared in large numbers.

Cultivation and Collection. In the Canaries, the insects are reared upon branches of various species of *Nopalea*, family Cactoceæ, plants commonly known as Indian Fig or Prickly Pear. Both male and female insects are quite small, about 1 mm. long and the male has four wings, while the female is wingless. After mating, the female pushes its long, delicate proboscis through the cuticle of the cactus and sucks its nourishment from the host plant. They increase in size till about 5 or 6 mm. long and numerous larvæ develop within them. When fully grown they are brushed from the cacti and are killed by exposure to fumes of burning sulphur or charcoal or to heat alone and are finally dried in the sun.

Description. The colour of the drug varies; some samples are very dark and are named "black grain" cochineal, while others are grey

and are termed "silver grain" cochineal. The difference arises from the method used for killing the insects; if killed by poisonous vapours, the natural waxy covering of the insects is unaltered and remains as a whitish granular film on the drug, giving "silver grain." If heat is

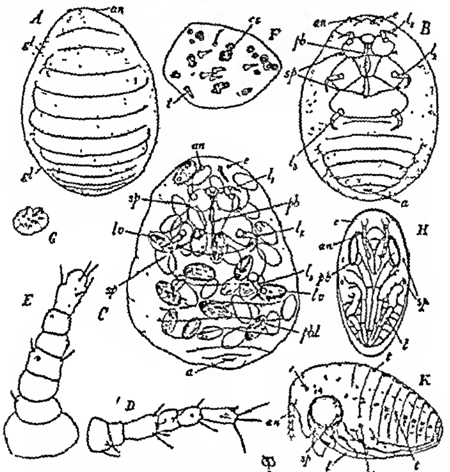


FIG. 131 Cochineal, *Dactylopuis coccus*. *A*, dorsal surface *B*, ventral surface *C*, insect as a transparent object, showing enclosed larvæ. *D*, antenna of larva. *E*, antenna of adult female. *F*, piece of dermis of an adult insect, showing hairs, truncate spines and grouped spinnerets. *G*, compound spinneret (group of wax glands). *H* and *K*, larvæ in different positions. *A*, *B* and *C* all × 9. *D*, *E*, *F* and *G* all × 150 *H* and *K* × 60. *a*, anus, *an*, antenna; *cs*, compound spinneret; *e*, eye, *gl*, wax-gland; l_1, l_2, l_3, legs of first, second and third pairs respectively, *lv*, larva, *pb*, proboscis; *pbl*, proboscis of larva; *sp*, spiracle; *t*, truncate spine (wax gland).

used, the wax is melted and forms a transparent varnish-like envelope, through which the dark colour of the insect itself is visible, thus giving the "black grain" variety. If insects are killed by immersion in hot water they have a red colour and form an article of inferior quality. The dried insects are brittle and easily reduced to a reddish or puce-coloured powder.

Each insect is plano-convex, [illegible] ersely, and oval in outline [illegible] They are about 3·5 to 5 [illegible] and each contains about 150, son[illegible], larvæ in various stages of development. The convex dorsal surface shows about eleven segments evenly spaced, there being no constrictions between the parts of the body. On the flat ventral surface the regions of the head, thorax and abdomen can be distinguished by the presence of appendages and the form of the segments. Close to the anterior end are the straight, seven-jointed antennæ and two eyes, each of a single lens; in the median line is the mouth with a long, thread-like, chitinous proboscis extending from it. The thorax carries three pairs of simple legs, each formed of three joints and a single claw; they are completely hidden beneath the body. At the margins of the joints between the thoracic sterna are four small spiracles in two pairs. The abdomen shows six or seven segments with the anus clearly marked at the posterior end. The larvæ are about 0·75 mm. long, each is enclosed in a delicate membrane—the skin of the egg—and has one prominent coil of two fine parallel chitinous threads on each side of the anterior part; these four threads ultimately form the proboscis of the mature insect. The whole surface of the insects is covered with scattered tubular wax-glands, about 20μ long, either single or in groups of two to six. In the larvæ the wax-glands are simple and are arranged in conspicuous longitudinal lines on the abdominal surface, see Fig. 131.

Constituents. Cochineal contains up to 10 per cent. of a red colouring matter, carminic acid, which is obtainable in small, red prismatic crystals; it is soluble in water, alcohol, and in alkaline solutions. The drug also contains fat (about 10 per cent.) and wax (about 2 per cent.), together with albuminoids, inorganic matter, etc.

Carmine is a preparation containing about 15 per cent. of water, 50 per cent. of carminic acid, 7 per cent. of ash, and about 20 per cent. of nitrogenous substances. It appears to be produced by precipitating infusions of cochineal by alum, in the presence of lime salts and either albumen or gelatin.

Adulterants. Cochineal is frequently adulterated by the addition of inorganic matter such as talc, barium carbonate and sulphate (for silver grain cochineal), or manganese dioxide, lead sulphide, magnetic iron sand, etc. (for black grain cochineal). These can readily be detected by means of the ash, which should not exceed 7 per cent., genuine cochineal of good quality yielding generally about 2·5 per cent. Silver grain cochineal, heavily "dressed," may yield up to 50 per cent. of ash.

CHAPTER XIII

RHIZOMES AND ROOTS

THERE is no clear division between roots and rhizomes in a commercial sense. When the presence of a rhizome is clearly obvious as in male fern, the drug is usually termed a rhizome. When the rhizome superficially resembles the root in size and appearance, as in dandelion and liquorice, the drug is usually described as a root, even when it consists mainly of rhizome or stolon. Hence commercial rhizomes almost always contain a considerable proportion of root and similarly commercial roots often consist of rhizome in the upper part. The general characters of roots and rhizomes may therefore be usefully discussed together.

RHIZOMES are stem structures growing horizontally, vertically or in an oblique direction at the surface of the ground in which much of the lower part is embedded. The *surface bears scale-leaves* with occasional *buds* in their axils and is often marked with the encircling *scars of fallen aerial leaves*, as in orris The lower surface of horizontal rhizomes and the whole surface of vertical and oblique rhizomes bear the *roots* which are usually slender and are adventitious. Scars of fallen roots appear as small circular marks.

The growth of the rhizome may proceed *monopodially* as in male fern and to a certain extent in orris, when the same growing point persists from year to year and produces the successive yearly portions of the rhizome In other plants such as podophyllum, the rhizome develops *sympodially*, each season's growth ending in a flowering stem, while the rhizome is carried forward by the development of a bud in the axil of one of the basal leaves of the stem. Each flowering aerial axis leaves its scar, usually a large circular one, on the upper surface of the rhizome. A vertical rhizome is often termed a *rootstock* and is usually not much greater in diameter than the main tap-root; the internodes are short and the surface has ring-shaped leaf-scars and often transverse wrinklings due to shortening to keep the crown at the ground level, as in gentian. A *stolon* is an underground stem similar in function to a runner, like that of a strawberry, but is much thicker and travels near or below the surface of the soil and roots at its extremity. Stolons form the bulk of the so-called root of liquorice, which will therefore be considered under the heading of rhizomes.

The transversely-cut surface of a rhizome is always characteristic and is also an aid in the botanical classification of the drug Thus if a number of separate steles are present, the drug is cryptogamic in origin, if a circle of bundles and a central pith, it is dicotyledonous, and if bundles are scattered more or less uniformly throughout stele and cortex and an endodermis is evident, the drug is monocotyledonous in origin. In rhizomes, the transverse surface never shows a central solid mass of xylem, a useful character which helps to distinguish rhizomes from roots.

Functionally rhizomes are organs of perennation and contain

reserves in the parenchyma, most commonly starch as in rhubarb and valerian. Inulin, sugar and other reserves also occur and afford characteristic appearances and tests.

A **corm**, being an underground axis, is closely related to a rhizome. It differs from a rhizome since one season's development only is usually present, the axis of the previous season having entirely disappeared. In a few plants, such as *Tritonia* (= *Montbretia*) the corms of successive seasons remain attached in a vertical row, forming a kind of rhizome and indicating the close relationship of corm and rhizome. Drugs derived from corms will therefore be included under the general heading of rhizomes.

ROOTS. The root is that portion of the plant axis, which, in seedlings, grows vertically downwards into the soil. When the primary root persists and is much more strongly developed than its branches, it is named a *tap-root*, as in aconite, belladonna, dandelion, etc. Roots bear only one kind of lateral appendage, namely, branches, which are similar in construction to the main root. The origin of the branches is described as *endogenous*, because the growing point arises in the outermost layer of the stele, in the pericycle, and the branch bores its way through the cortical tissues by the secretion of enzymes. The branches are arranged in regular vertical lines, since they arise opposite to the protoxylem groups of the vascular system. There are therefore as many *rows of lateral branches* as there are protoxylem groups in the stele. Sometimes two rows of lateral roots arise opposite each protoxylem mass thus giving double rows of lateral roots. Roots bear no leaves or buds, so that there are no external leaf-scars or roots. As the young root descends into the soil, it meets with obstacles and turns aside to avoid them; as a result roots are rarely straight, and most drugs consisting of roots are therefore more or less *tortuous*.

The appearance of the smoothed transversely cut surface of a root differs in dicotyledons and monocotyledons. In dicotyledons, to which the majority of drugs occurring as roots belong there is a *central woody core* surrounded by the cambium, a cylinder of secondary phloem and covered externally by a layer of cork. After secondary growth has commenced, the phellogen arises in the pericycle so that in all dicotyledonous roots of any size, the whole of the cortex is exfoliated and most commercial roots show *neither pith nor cortex*. The root of aconite is an exception in both of these respects, because no phellogen is formed and there is a large pith which increases in bulk as the root matures.

In monocotyledonous roots, a pith is usually present and is often composed of thick-walled lignified cells; the xylem is porous and a cortex is present and frequently also root-hairs, as is the sarsaparillas.

Collection and Drying of Rhizomes and Roots. Roots and rhizomes are usually collected when their tissues are fully stored with reserve foods, it being assumed that medicinal constituents will be also most abundant at this season. In Britain and other temperate regions autumn is therefore the season for collection. Large roots and rhizomes are generally sliced transversely or longitudinally or in both directions to facilitate drying. They are usually spread out on a floor

or shelves, which in suitable weather may be arranged out of doors under a roof so that the warm air may blow through them. In Britain some artificial heating must almost always be employed and a quite gentle heat is used at first to avoid gelatinisation of starch. After partial drying, the temperature is raised as drying approaches completion. Care must be taken that the finished drug is completely dry to the centre as evidenced by its breaking with a short, crisp fracture, carelessness in this operation leads to the appearance of moulds during storage. Most roots and rhizomes require from ten days to three weeks to dry thoroughly. Some roots develop their important constituents as a result of fermentation during drying, which is then a prolonged operation carried out at a low temperature. In tropical and sub-

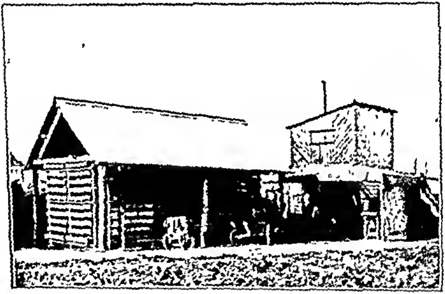


Fig. 132. Drying dandelion root in the open air. (After Greenish.)

tropical countries the heat of the sun is commonly used for drying operations.

Roots and rhizomes, which are *transversely sliced* preparatory to [illegible] rhubarb, marshmallow.

Histology of Rhizomes. Rhizomes, being modified stems, possess a structure having a general resemblance to that of aerial stems. Since, however, rhizomes grow at or below the ground level, they have no need to develop a structure which would enable them to support themselves in a rare medium, like air, or to resist lateral stresses such as result from violent winds. The supporting tissues in rhizomes are, therefore, ill-developed and an arrangement of either xylem or sclerenchyma [illegible]

in ginger and liquorice. Nothing in the nature of rhytidoma is developed. *Cork is sometimes replaced by a modification of the outer layers of the cortex.* The walls of these cortical cells become suberised and form a protective tissue named *metaderm*, as in veratrum rhizome. The metaderm is easily distinguished from cork because its cells are rounded and are not arranged in radial rows.

The *cortex* usually consists of thin-walled parenchyma containing reserves, such as starch. The endodermis is not differentiated and there is an absence of sclerenchyma and supporting tissues in all large bulky rhizomes, such as rhubarb and ginger, but in some of the slender monocotyledonous rhizomes, such as couch grass, sclerenchyma is present and is arranged in a tubular formation and a well-developed endodermis *surrounds the stele.*

The *stele* in rhizomes shows the arrangement characteristic of the group of plants to which the rhizome belongs. For this reason, as pointed out above, the transversely cut surface of a rhizome affords a useful character of identification. The male fern has a characteristic dictyostele; some dicotyledons, such as podophyllum, have a circle of separate bundles and show an absence of interfascicular cambium. In other dicotyledons, such as liquorice and ipecacuanha, a complete cambium ring is formed and secondary xylem and phloem are developed as in aerial stems. Monocotyledonous rhizomes usually possess a definite endodermis, near which numerous smaller vascular bundles occur, while larger bundles are found *towards the centre, scattered throughout the ground tissue, and leaf-trace* bundles are fairly numerous in the cortex. The tegumentary tissue may be cork as in ginger, or metaderm as in veratrum, or epidermis as in couch grass.

Histology of Roots. Roots of vascular plants belonging to different groups show a close similarity in their primary structure. *Externally* there is a piliferous layer, covering the parenchymatous cortex, the outer layer of which is sometimes specially differentiated, as in *Smilax ornata*, when it is known as the exodermis. The endodermis is generally well-marked and has either a strongly developed casparian strip or some special form of thickening. The stele is surrounded by a single layer of pericycle and has bundles of xylem and phloem arranged in a circle, alternating in position so that each lies on a different radius. The bundles are all centripetal in development, and the xylem bundles frequently develop until they meet at the centre of the root, forming a rod-shaped mass of xylem. The type of xylem mass so formed is named according to the number of points of origin, the groups of protoxylem, concerned in its formation. Roots are therefore described as diarch, triarch, tetrarch, polyarch, etc., from the Greek word *arche*, an origin, and the appropriate Greek numeral as a prefix.

Pteridophyte roots are usually very simple and slender and they permanently retain the primary structure; the roots of *Dryopteris Filix-mas* are diarch. The slender roots of many rhizomes also show a well-marked primary structure, which in dicotyledonous plants, such as *Helleborus niger*, which is four- to five-arch, and *Podophyllum peltatum* which is four- to nine-arch, may show a slight amount of secondary development in the older parts, which are the portions of the roots nearest to the rhizome.

Other dicotyledonous roots, which grow to a large size, such as belladonna and gentian, develop a cambium on the inside of the primary phloem bundles and outside the protoxylem groups; these cambia unite into a wavy line which ultimately becomes rounded out into a circle. The greater activity of the cambium on the inside of the phloem bundles forms wedges of secondary xylem and the cambium and phloem are carried outwards until they are equidistant radially with the cambium outside the

protoxylem groups. Opposite each protoxylem group the cambium usually forms parenchyma only, thus giving rise to the largest medullary rays which can be easily observed in the transverse section of almost any dicotyledonous root. At the centre of a section of such a root careful inspection will always reveal the primary xylem bundles. See Fig. 133.

Cork formation takes place at a deeper layer than in stems, the phellogen arising in the pericycle. This formation of cork results in the death of the

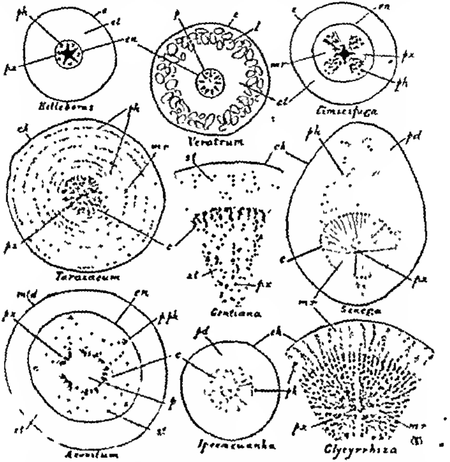


FIG. 133. Diagrams of transverse sections of typical roots. All × 8. *c*, cambium; *ck*, cork; *ct*, cortex; *e*, epiblema; *en*, endodermis; *l*, lacuna; *mr*, medullary ray; *md*, metaderm; *p*, pith; *pd*, phelloderm; *ph*, phloem; *p.ph*, primary phloem; *p.x.*, primary xylem; *st*, sieve tissue. *Note* that *Senega* and Taraxacum are *diarch*. Gentian and Ipecacuanha are *triarch*. Cimicifuga and Glycyrrhiza are *tetrarch*. Helleborus and Aconitum are *pentarch*. Veratrum is *polyarch*.

endodermis, cortex and piliferous layer, all of which are ultimately rubbed off. Large dicotyledonous roots, such as belladonna, gentian and ipecacuanha, therefore show a complete absence of cortical tissues. The phellogen cuts off cells on the inner side and these constitute a phelloderm, which is often largely developed, as in ipecacuanha, and becomes stored with reserves such as starch.

Monocotyledonous roots are usually described as polyarch and generally have from eight to thirty primary xylem bundles. Roots of *Veratrum*

viride, family Liliaceæ, are about nine-arch, those of *Acorus Calamus*, family *Aroideæ*, are about ten-arch and those of *Smilax ornata*, family Liliaceæ, are about thirty-arch. In monocotyledons a pith is usually present and its cells often become thick-walled and lignified as in *Smilax sp.*, the sarsaparilla.

Occasionally the stele of a dicotyledonous root, such as the eleven-arch stele of *Menyanthes trifoliata*, family Gentianaceæ, so nearly resembles that of a monocotyledon that it is almost impossible to refer the plant to its group by this character.

The degree of development of the tissues varies so much in different plants that transverse sections of roots with secondary thickening present wide differences. In *Gentiana lutea* and *Atropa Belladonna* the parenchyma of the xylem is extensively developed, the vessels being scattered throughout it in small groups; the secondary phloem in these roots is a narrow band. Hence the great bulk of the roots is composed of xylem parenchyma. In *Taraxacum officinale*, the xylem is quite small, but the secondary phloem is unusually large, showing concentric rings of sieve-tissue and laticiferous vessels alternating with rings of parenchyma. In *Cephaelis Ipecacuanha*, the xylem is small, the phloem also is feebly developed, but externally there is a very wide layer of starch-bearing parenchyma constituting the phelloderm. In *Aconitum Napellus* a large pith is present, the amount of xylem and of sieve-tissue is small, but the medullary rays are wide and much parenchyma is developed in all parts. In *Polygala senega* one or, more rarely, two medullary rays are exceptionally large, giving the appearance in transverse sections of one or two wide wedges of parenchyma inserted into the compact central mass of xylem. In *Cimicifuga racemosa* the four primary medullary rays are very wide, dividing the secondary xylem into four comparatively narrow arms, which give the appearance of a Maltese cross in transverse sections, see Fig. 133.

Abnormal developments occur in certain roots. In *Atropa Belladonna* and in *Gentiana lutea* numerous small groups of sieve-tissue are embedded in the secondary xylem and are described as interxylary phloem. These plants have perimedullary phloem in the stem. In *Convolvulus Scammonia*, *Ipomœa purga* and *Ipomœa orizabensis* tertiary cambia arise in the parenchymatous secondary xylem and produce xylem internally and phloem externally. The cambia in *C. Scammonia* are usually circular, having arisen around a vessel or a small group of vessels. In *I. purga* they are short curved or wavy lines or sometimes circles and in *I. orizabensis* and *Phytolacca sp.* the cambia form concentric circles, successive cambia arising in the pericycle as the roots increase in girth.

Classification of Rhizomes

1. *Vertical and Oblique Rhizomes.*
   Male Fern, Valerian, White Hellebore, Green Hellebore, Rhubarb, Sumbul.
2. *Horizontal Rhizomes.*
   (a) *Dicotyledonous.*
   Podophyllum, Bloodroot, Arnica, Indian Valerian, Hydrastis, Indian Podophyllum, Serpentary, Liquorice, Gelsemium.
   (b) *Monocotyledonous.*
   Turmeric, Ginger, Galangal, Orris, Acorus, Couch grass.
3. *Corms.*
   Colchicum, Indian colchicum.

MALE FERN RHIZOME. Rhizoma Filicis Maris, Filix Mas

Sources. Male fern rhizome consists of the dried rhizome and frond bases of *Dryopteris Filix-mas* (Linn.), Schott, family Polypodiaceæ, a fern which is abundant in Great Britain, and on the continent of Europe. Much is imported from Germany, large quantities being collected in the Harz and Thuringian Mountains. It is also imported from India.

Collection. The Male fern plant is recognised by its stout, oblique rhizome, bearing a crown of about eight to ten erect fronds which are about

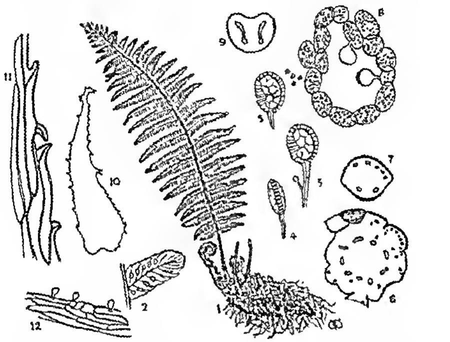


FIG. 134 Male fern, *Dryopteris filix-mas* 1, Habit sketch with rhizome 2, Pinnule, showing sori with reniform indusia. 3, 4 and 5, Sporangia, showing annulus and spores 6, Transverse surface of rhizome with frond bases and nine meristeles. 7, Transverse section of a frond base. 8 Intercellular space in the ground tissue, showing secreting glands. 9 Frond base of lady-fern, *Athyrium Filix fœmina*. 10 Outline of a ramentum × 8 11, Margin of ramentum with two-celled teeth. 12. Margin of ramentum of *Aspidium spinulosum*.

1 metre long The fronds bear about forty to fifty pairs of pinnæ, each about 15 cm. long and having twenty to thirty pairs of pinnules, which are oblong and serrated towards the tips, which are blunt. Eight to ten sori are present on each pinnule; they have reniform indusia, each attached by the notch to a veinlet.

The rhizomes are dug in the autumn; after washing, the wiry roots, the dead parts and the fronds, except their bases, are cut away and the trimmed rhizomes are dried at a gentle heat. Large rhizomes are sometimes halved longitudinally to facilitate drying.

Description. The dried rhizome of commerce occurs in brownish-black, ovoid-cylindrical pieces about 6 to 16 cm. long and 3 to 4 cm. in diameter; they are only rarely branched. The surface is closely covered

by the frond-bases, which have a phyllotaxis of 3 : 8, being arranged in two sets of crossing spirals. The frond-bases are inclined towards the apex at an angle of about 30 degrees from the vertical, indicating that, when in the ground, the rhizome itself is inclined at the same angle from the horizontal. The apex of the rhizome is covered by young fronds with circinate vernation. Each frond-base is about 3 to 6 cm. long and 5 to 8 mm. thick, slightly curved longitudinally with t [illegible]
Both t [illegible]
numer [illegible]
a triangular-lanceolate plate, one cell thick and about 10 to 30 mm. long. The rhizome itself is about 2·5 cm. thick and both frond-bases and rhizome break with a short fracture, exhibiting a green and starchy interior. The transversely cut surface of the rhizome is irregular in outline from the presence of the partly adherent frond-bases; it shows seven to nine vascular strands (meristeles) of varying sizes arranged in a circle, an appearance resulting from the presence of a dictyostele. The transversely cut surface of a frond-base is oval with two projections towards the upper less-curved side and has seven to nine small meristeles in a circle, see Fig. 134.

The drug is odourless, but has a disagreeable, nauseous and bitter taste.

Histology. The ground-tissue of the rhizome and frond-bases consists of a round-celled parenchyma containing abundant starch grains, which are simple, rounded, and about 12 to 25 microns in diameter. Many of the intercellular spaces are large, lined by a thin cuticle and projecting into them are unicellular sub-spherical or club-shaped internal trichomes, which secrete a greenish oleo-resin. The hypodermal layer consists of two or three rows of fibrous sclerenchyma which has brown walls, but is not lignified. The meristeles contain from one to three bundles, which are concentric with central xylem consisting chiefly of large prismatic scalariform vessels having pyramidal ends and from 10 to 50 microns wide; embedded in the xylem are from one to three protoxylem groups consisting of small spiral vessels; each meristele is surrounded by an endodermis. The ramenta are composed of thin-walled, somewhat elongated cells and have marginal teeth each consisting of adjacent projecting portions of two cells. Calcium oxalate is absent.

Constituents. The chief constituent of male fern rhizome is about 5 per cent. of a yellow, amorphous substance of acid nature termed [illegible]

constituents are formed by the internal secreting trichomes of the rhizome and frond-bases. The drug yields about 4 (not over 6) per cent. of ash.

[illegible]

The rhizome of *A. Filix-fœmina* may be easily distinguished by the number of bundles in the leaf-base, for whilst the male fern has from seven to nine the lady fern has only two large ones. Moreover, the lady fern produces no secreting cells in the parenchyma of rhizome or petiole. It has decided anthelmintic properties, and contains filicic acid and possibly filmarone also. It is seldom found in the commercial drug

The rhizome of *D. spinulosa* is more difficult to distinguish, as it contains secreting cells similar to those of the male fern, and about the same number of bundles. The character of the margin of the ramenta is distinctive, those of *D. spinulosa* bearing numerous unicellular, spherical, glandular trichomes. The rhizome of *D. spinulosa* is frequently found mixed with the male fern in German commerce (up to 90 per cent.). It is an active vermifuge, and is largely used in Finland. It contains aspidin (polystichin), polystichinin, polystichalbin, filicic acid and probably filmarone. The extract prepared from it is said to be twice as active as that from *D. Filix-mas*.

VALERIAN RHIZOME. Rhizoma Valerianæ

Sources. Valerian rhizome consists of the dried rhizome and roots of *Valeriana officinalis* Linn., family Valerianaceæ, a plant which is indigenous to Europe and northern Asia. It is cultivated in England, Holland and Belgium and in Germany.

Cultivation and Collection. The vertical rhizome of the valerian plant bears small horizontal branches or stolons at about the ground level and each of these develops a small rhizome or offset at the distal end Young offsets from wild plants are collected in the spring and are planted in a well-manured field of calcareous alluvial soil, in rows about 30 cm. apart. The large rhizomes begin to throw up flowering stems which are cut off about a month after the plants are set; the smaller rhizomes form rosettes of leaves. In September or early in October the whole of the tops above ground are cut off with a scythe and the rhizomes are dug up. They are washed in running water, the larger ones are sliced longitudinally or transversely and together with the entire smaller rhizomes are dried slowly by spreading them on a floor perforated with holes and heated by a coke stove beneath it Drying is usually complete about December.

Description. Valerian rhizome is yellowish-brown, bluntly conical, up to 12 mm thick and 25 mm. long; small rhizomes are about 3 mm. thick and 5 mm. long. The small rhizomes are sometimes attached to larger ones by short runners or stolons about 2 5 cm. long. The larger rhizomes are often halved vertically or sliced transversely, the smaller ones are entire. They are crowned by the remains of stems and leaves and the tapering under-surface is thickly clothed with adventitious roots, which are sometimes striated, but are usually plump, up to 10 cm. long and about 2 mm. thick; where the roots have broken away, circular scars are left. The exposed inner surface of sliced rhizomes is firm and more or less horny or starchy; sometimes they are rather hollow, portions of the pith remaining as transverse septa. The smoothed transversely cut surface exhibits a central pith, about two-thirds of the total diameter, surrounded by a ring of small xylem bundles, beyond which is a cambium line and a narrow phloem divided from the cortex by a line which is the endodermis; root-trace bundles leave the main bundles and cross the phloem and cortex to the root-

bases. The longitudinally cut surface closely resembles the transverse one, but the circle of bundles is less marked, being completed above and below by leaf-trace and root-trace bundles respectively. The roots often show a small central pith in a stele surrounded by an endodermis, beyond which is a fairly wide cortex covered externally by the epiblema.

The drug has a penetrating unpleasant odour and a camphoraceous, slightly bitter taste.

Histology. The chief microscopical features are the stout-walled rounded-oblong parenchyma containing abundant starch grains 3 to 12 to

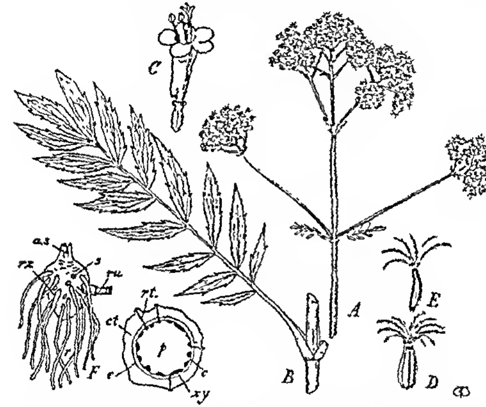


FIG. 135. *Valeriana officinalis.* *A*, inflorescence. *B*, foliage-leaf. *C*, flower. *D*, fruit. *E*, longitudinal section of fruit. *F*, rhizome and its transversely cut surface. *a.s.*, aerial stem ; *c*, cambium ; *ct*, cortex ; *e*, endodermis ; *p*, pith ; *r*, adventitious root ; *r.t.*, root-trace ; *ru*, runner ; *rz*, rhizome ; *xy*, xylem.

20 microns in diameter, either simple or two- to six-compound ; slender pitted, spiral and annular vessels in small numbers ; rectangular prismatic [illegible]

Constituents. The principal constituent of valerian root is the volatile oil which is contained in the hypodermis of the roots and in [illegible] Good valerian root yields about 1 per [illegible] nts of which is bornyl iso- [illegible] decomposed by an enzyme [illegible] an oily liquid possessing a characteristic odour ; to this body the unpleasant odour of valerian

root is to be ascribed, and its gradual production from bornyl isovalerianate explains the development of the odour as the root dries, the fresh root having only a slight odour.

Valerian root also contains two alkaloids, chatinine and valerianine, resin and mucilage.

Uses. The drug is used as a powerful carminative, stimulant, and antispasmodic; it is given chiefly in hysteria, palpitation of the heart, etc.

Substitutes, etc. *Japanese Valerian, Kesso*; is said to be the rhizome and roots of *Valeriana officinalis* var *latifolia* Miquel; rhizome small, erect, crowned with scars or with the remains of aerial stems; brownish; odour resembling that of valerian but much stronger and somewhat aromatic; yields up to 8 per cent. of volatile oil containing *l*-bornyl isovalerianate and acetate, kessyl acetate, and terpenes

Radix Valerianæ Majoris is the root of *V. Phu* Linn.; it has very little odour.

Mexican Valerian is the rhizome of *V. officinalis* growing in Mexico, it yields traces of volatile oil and a little free valerianic acid; the odour is feeble.

Nardus root is the rhizome and roots of *Nardostachys Jatamansi* de Candolle, family Valerianaceæ, Alpine Himalayas; rhizome short, thick, dark grey, crowned by a bundle of fibres; odour resembles valerian; yield of oil about 1 per cent.

WHITE HELLEBORE RHIZOME. Rhizoma Veratri Albi

Sources. White hellebore, *Veratrum album* Linn., family Liliaceæ, is an herbaceous plant with erect perennial rhizome, common on the mountains of central and southern Europe. It produces large, ovate, ribbed leaves and a flowering stem that attains a height of a metre or more. The rhizome appears to have been known and used medicinally for many years, but owing to its powerful and uncertain action it has been employed chiefly as an external application.

Collection. The rhizome is dug up in the autumn, and the leaves which are all radical until a flowering stem is produced, are cut off close to it. It is then usually dried entire, but is sometimes cut longitudinally into halves or quarters to facilitate drying, sometimes deprived of its roots and occasionally sliced transversely. The separation of the roots is to be deprecated, as they appear to be more active than the rhizome When fresh the rhizome has an alliaceous odour, but this is lost by drying

Description. White hellebore rhizome (when freed from the roots) averages about 5 cm. in length and 2 cm. in thickness, and is of a dull black colour externally. The upper part is nearly cylindrical, but the lower extremity, where the rhizome gradually perishes and rots away as growth progresses, is usually bluntly conical or truncate. It is crowned with a dense leafy mass consisting of the thin, dry remains of numerous concentrically arranged leaf-bases which have been cut off level close to the rhizome; the outer of these are coarsely fibrous, the parenchymatous tissue having perished, leaving the veins persistent. The surface of the rhizome is rough and wrinkled; in the centre of each root-scar a slender xylem is distinctly visible. In the untrimmed rhizome the roots are very numerous and stout they completely envelop the rhizome, so that the untrimmed drug is much more bulky than the rhizome alone; they are usually dull grey or yellowish in colour, and commonly show a disposition to shrivel longitudinally rather than transversely.

The rhizome frequently divides into two or even three branches.

The drug breaks with a short fracture, the interior being whitish, firm, compact, and starchy. The cortex is about 3 mm. thick, and is limited internally by a brownish line, the endodermis; the stele occupies the central region, 1 to 1·5 cm. in diameter.

Scattered vascular bundles are present in both cortex and stele, being most numerous in the outer part of the stele. Occasional vascular bundles traverse the cortex from the pericycle to the bases of the adventitious roots; at the centre of the stele the bundles are often somewhat elongated, being cut obliquely. Well-developed lacunæ are present in the outer part of the cortex of the roots and the stele has a central pith surrounded by a ring of alternating bundles of xylem and phloem.

The drug has a bitterish, acrid taste, but little odour; the powder is strongly sternutatory.

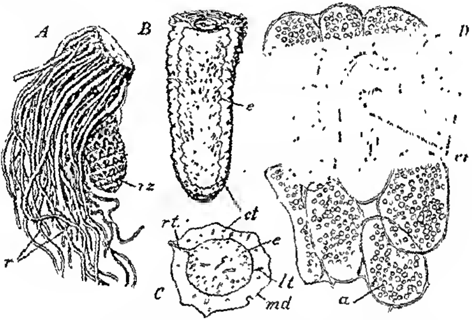


FIG. 136 *Veratrum album.* White hellebore. *A*, entire rhizome with roots *B*, rhizome cut longitudinally. *C*, rhizome cut transversely. *D*, part of a transverse section × 250 *a*, starch; *cr*, bundle of acicular crystals of calcium oxalate; *ct*, cortex; *e*, endodermis; *l.t.*, leaf-trace; *md*, metaderm; *r*, adventitious roots; *r.t.*, root-trace; *rz*, rhizome. (*A* and *B* from the *Pharm Journ.*)

Constituents. White hellebore contains several alkaloids, the total amount varying from 1 to 2 per cent. and averaging about 1·3 The most important and the most toxic of these is protoveratrine, which closely resembles aconitine in its action, and is in addition a powerful sternutatory. Jervine is also crystalline and toxic, but it is less active than protoveratrine. Rubijervine and pseudojervine are also present, but are said to be inactive. Whether protoveratridine occurs preformed in the drug is doubtful. The roots appear to be somewhat richer in alkaloid than the rhizome (Bredemann, 1906), and therefore should not be discarded.

White hellebore also contains resin and starch.

Uses. White hellebore is a powerful emetic and purgative when administered in full doses. It has been prescribed for gout, but is now usually employed as an external application in certain skin diseases, for the destruction of pediculi and other noxious vermin, and as a moth-powder.

AMERICAN VERATRUM. Green Hellebore, Rhizoma Veratri Viridis

Sources. *Veratrum viride* Aiton, family Liliaceæ, is a plant closely resembling *V. album* It is common in the eastern United States, growing in rich woods. The plant is dug up in the autumn, the leaves are cut off close to the crown, and the rhizome is then usually halved or quartered to facilitate drying; occasionally the roots are cut off ("trimmed" rhizomes), but more frequently they are left attached to the rhizome ("with fibre").

The drug is commonly termed "green hellebore," but this name is better restricted to the rhizome of *Helleborus viridis* Linn; American veratrum is a more suitable designation.

Description. The rhizome closely resembles that of *V. album*, the American veratrum, however, is usually cut longitudinally, whilst white veratrum is commonly entire, other characters are the brighter, yellowish-brown colour and the more transversely shrivelled appearance of the roots. According to Viehover, Kleenan and Clevenger (1921) the endodermal cells of *V. viride* are U shaped and evenly thickened, while those of *V. album* are V shaped. These characters, however, vary to a considerable degree.

Constituents. The constituents of *Veratrum viride* are apparently identical with those of *Veratrum album*, with the (doubtful) exception that the former contains an alkaloid—cevadine—that is not found in the latter; they are present in about the same proportion.

Uses. American veratrum has been recommended as a sedative, but is seldom prescribed for internal administration. See under White Hellebore.

RHUBARB. Rhizoma Rhei, Radix Rhei, Rhubarb Rhizome

Sources. Rhubarb consists of the peeled and dried rhizomes of various species of *Rheum*, family Polygonaceæ, growing in China and Thibet. A comparison of the structure of commercial rhubarb with that of the known species of *Rheum* indicates that it is derived from *Rheum palmatum* Linn. and from *R. officinale* Baillon. The botanical source of rhubarb coming from the province of Shensi is still uncertain; it appears to be derived from a third species of *Rheum*. *R. palmatum* grows abundantly near Lake Kokonor and its rhizome is collected in Thibet and in the province of Kansu; merchants from Shansi and Canton purchase this rhubarb and carry it to Hankow, whence it comes eventually to Shanghai. Rhizomes of *R. officinale* are collected in the province of Sze-chwan, whence they are transported *via* the Yang-tse-kiang to Shanghai.

History. That the Chinese were acquainted with rhubarb many centuries B.C. is evident from the fact that it is named in the herbal, "Pen-king," which is attributed to the emperor Shen-nung about 2700 B.C. As early as 114 B.C. the drug was brought by trading caravans from Shensi in north China to Bokhara in Russian Turkestan and thence came to Europe, probably *via* the Black Sea. Dioscorides, the Greek writer, about A.D. 77, refers to this drug as *rha* or *rheon*; he did not know its source, but described it as coming from countries beyond the Bosphorus. The names *rheum barbarum or reu barbarum* were used by Latin writers of about 550 A.D. and probably indicates *rha* or rhubarb from a barbaric country, possibly Turkey. The same terms are used by Arabian physicians, writing during the eleventh century. From these origins we derive the modern name rhubarb.

From the twelfth to the eighteenth century rhubarb was carried from China to Persia by caravan and thence to Aleppo, Tripoli, Alexandria and Smyrna. From these Levant ports the drug was shipped to Europe and

became known as **Turkey Rhubarb.** During the same period some rhubarb was shipped from Chinese ports and came to Europe by way of India and was known as China, Canton or **East Indian Rhubarb.** In 1728 Russia obtained a monopoly of the Chinese trade in rhubarb by caravan and since the only free Chinese port was Canton, the bulk of the best rhubarb, coming to Europe between 1728 and 1860, passed through Russia *viâ* Moscow and not by the Levant ports as formerly. This Russian or **Muscovitic Rhubarb** was still usually known in Britain as Turkish Rhubarb, the name having been transferred. Small quantities of East Indian rhubarb still came from Canton *viâ* India.

On the opening to trade of several of the northern Chinese ports in 1842, the Russian trade rapidly diminished and the bulk of rhubarb began to come and still comes directly from China to Europe.

Collection and Preparation. The large rhizomes of plants about six to ten years old, growing at elevations of 3,000 to 4,000 metres in the province of *Sze-chwan*, are lifted from the ground chiefly in September and October. The roots are cut off and the rhizomes cleaned, the crown is then cut out and the bark removed; the larger rhizomes are cut transversely or longitudinally or in both directions. The pieces are then pierced by holes and are threaded on to cords, which are stretched from tree to tree in the shade or under the eaves of the roofs of houses. Sometimes, however, they are spread on hurdles in huts and dried by the heat of fires or they may be placed on stones—"stone tables"—previously heated by burning small twigs upon them. The prepared rhizomes are transported to Chungking on the Yang-tse-kiang and so by river to Shanghai, whence they are shipped to Europe.

Description. Rhubarb rhizome occurs in pieces which are described as "flats" and "rounds." The "flats" are formed from large rhizomes, which have been divided longitudinally and are plano-convex, tapering slightly towards each end and are about 7 to 10 cm. long and 3 to 6 cm. thick at the middle point. "Rounds" are formed from rather smaller rhizomes, which are not divided longitudinally and consequently cylindrical, barrel-shaped or conical, being about 8 to 10 cm. long and 4 cm. thick. The outer surface is commonly dusted over with powdered rhubarb, in the form of a fine yellow powder, to give them a good appearance. After removing the powder, the surface shows flattish longitudinal areas, resulting from the use of a knife for cutting away the bark, and may also show marks produced by filing or scraping, which is done after drying so as to remove discoloured patches. Dark areas may still be found here and there. On many pieces of *Shensi* rhubarb there is visible a delicate network of white lines, the rhomboid meshes of which are about 1 to 1·5 mm. wide by 2 to 2·5 mm long, each being filled by a number of fine vertical reddish-orange lines embedded in a white matrix. The reddish-orange lines are the medullary rays seen in a tangential section of the rhizome and the white tissue is phloem or xylem parenchyma filled with starch and calcium oxalate. This pattern is therefore evidence that in paring the rhizome the cortex has been removed, but not the whole of the normally developed radiate secondary phloem and xylem. The outer surface may also exhibit occasional small dark points or projections, which when carefully shaved off appear as radiating white and reddish-orange lines, showing that they are leaf traces. If the trimming has been very severe, there may be seen upon the surface numerous groups, each

about 3 to 8 mm. in diameter, of radiating dark reddish-orange lines known as *star-spots*, which result from the sectioning of abnormal vascular strands occurring in the pith.

The smoothed transversely cut surface may show just within the outer margin, a fairly continuous cambium line with portions of phloem

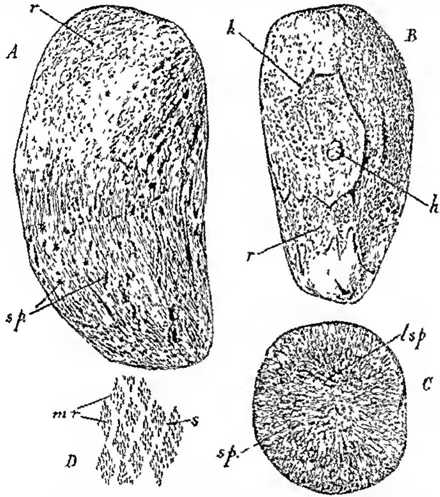


Fig 137. Chinese rhubarb Shensi *A*, Shensi flat *B*, Shensi round. *C*, end of Shensi round. *D*, detail of the reticulations × 3. *h*, hole with embedded string; *k*, knife-mark, *l.s.p*, star-spot cut longitudinally, *m r*, medullary ray; *r*, reticulation; *s*, starchy parenchyma; *s p*, star-spot (*A*, *B* and *C* from *Pharm Journ*)

external to it, excepting where this has been cut away during the preparation of the drug Within the cambium is a ring, about 5 mm. wide, of radiate secondary xylem with reddish-orange medullary rays, the remainder of the surface is occupied by the large pith In the periphery of the pith, immediately within the secondary xylem, is an almost continuous ring of star-spots and scattered throughout the remainder of the pith are star-spots and irregular markings composed

of more or less parallel straight or undulating reddish-orange lines embedded in a starchy, parenchymatous matrix. See Fig. 138*A*.

The inner surface of a "flat" shows numerous transverse lines of star-spots and also undulating groups of transversely placed parallel reddish-orange lines.

The drug is firm, heavy, and compact, the outer surface showing little sign of shrinkage during the drying; it breaks with an uneven short fracture, the fractured surface, which varies from bright pink to dull grey in colour, exhibiting numerous small dark reddish-orange lines alternating with white ones, known as "nutmeg" fracture.

Three varieties of Chinese rhubarb are recognised on the market, viz. Shensi, Canton, and High-dried, each of which may occur in "flats" or "rounds."

Shensi rhubarb is the variety described above; it is characterised by its very compact nature, bright yellow coat, distinct whitish reticulations, and "nutmeg" fracture: the odour is agreeable and free from marked empyreuma, the taste slightly bitter; that which exhibits a bright pink fracture is preferred.

Canton rhubarb may be distinguished from Shensi by the fracture, which is more or less uniformly granular, exhibiting no marked marbling, and by the odour and taste which are more distinctly empyreumatic and disagreeable. It is more fibrous in its nature and less compact, the coat is not so bright, and the whitish reticulations are less marked. Formerly the pieces bore a deep triangular nick, but this is now more often wanting. It is less esteemed than Shensi rhubarb.

High-dried rhubarb may resemble either Shensi or Canton in the fractured surface, but the coat is much duller and rougher, and the odour and taste more empyreumatic than Canton. The rounds are often much shrunken, and frequently exhibit the remains of the bud, dark patches being often visible on the outer surface. The flats show distinct severe paring, and are often so hard as to spring when broken with the hammer; they are usually of better quality than the rounds.

The complex structure of this drug is due to the fact that it is a very fleshy rhizome, the internodes of which are so closely approximated as to be almost suppressed and having an abnormal development of bundles in the pith.

The drug possesses a characteristic odour and bitter, astringent taste; when chewed it is very gritty between the teeth, a character due to the calcium oxalate, which occurs in considerable quantity in large cluster crystals.

Histology. The general arrangement of the tissues of rhubarb is described above. The abundant parenchyma, present in all parts, contains starch grains, which are either simple or two- to five-compound, individual grains being 4 to 18μ in size; the compound grains may reach a diameter of 30μ. Single grains are rounded, components of compound grains are often muller-shaped and the hilum frequently has the form of a radiate split. Many cells of the parenchyma contain cluster crystals of calcium oxalate, having a diameter of 20 to 200μ, including a considerable number over 100μ; they are so large that many of them are broken into fragments during the process of powdering the drug. The cells of the medullary rays, both in the normal radiate xylem and phloem and in the

star-spots, contain yellow masses, which are insoluble in alcohol, but soluble in water, and are coloured reddish-pink by solution of ammonia and deep blood-red by caustic alkali The xylem vessels are mostly reticulate and are remarkable because their walls are cellulosic and give no reactions for lignin. The star-spots have a small amount of collapsed phloem at the centre; this is surrounded by phloem developed from the cambium, which arises round the original strand of phloem; externally the cambium forms xylem with large vessels; the radiating orange arms of the star are the medullary rays. The older star-spots frequently show

Fig 138 Shensi rhubarb. *A*, transversely cut surface of a flat × 1 *B*, transverse section through a star-spot × 25 *C*, transverse section of fundamental parenchyma × 130 *a*, starch, *c*, cambium; *cr*, cluster crystal of calcium oxalate, *c s t*, central sieve-tissue, collapsed; *m r*, medullary ray, *ph*, phloem, *sp*, star-spot; *sp l*, star-spot cut longitudinally, *s t*, sieve-tissue, *v*, xylem vessel, *xy*, normal secondary xylem.

mucilage cavities in the phloem just within the cambiform tissue. There are no sclerenchymatous fibres or cells and commercial rhubarb has no cork, because it has been cut away during preparation of the drug.

The *star-spots* arise as a result of the development in the pith of supernumerary concentric bundles having phloem towards the centre and xylem externally. In the periphery of the pith are a number of vertical strands of phloem and at the nodes there are numerous similar horizontal strands forming a kind of network diaphragm across each node. All these strands become surrounded by cambia which develop phloem on the inside and xylem outside with radiating slightly curved medullary rays; when cut across transversely a star-spot results. One finds, therefore, in a transverse

Constituents. Rhubarb contains derivatives of anthraquinone, which are regarded as the purgative constituents and are present to the extent of 2·0 to 4·5 per cent. The astringent constituent consists chiefly of gallic acid in the form of glucogallin, which is glycosidal, together with small amounts of tannin and possibly catechin. Other constituents, apparently devoid of medicinal action, are rheinolic acid, starch, fat, dextrose, levulose, pectin and calcium oxalate. The amount of calcium oxalate, and consequently also the ash, varies widely, the ash is from 3·5 to 43·3 per cent., good Chinese rhubarb yielding from 7 to 13 per cent. That the ash is due almost entirely to calcium oxalate is evident from the small acid-insoluble ash, which should not exceed 1 per cent.

The anthraquinone derivatives present in rhubarb are rhein, emodin, aloe-emodin, emodin-monomethyl-ether and chrysophanol. These occur partly fr
other undetermined
mass, extracted from
"rheonigrin," which yields upon hydrolysis gallic and cinnamic acids together with the anthraquinone derivatives named above.

The presence of anthaquinone derivatives may be demonstrated by the following test: Boil 0·1 gm. of the drug in powder with 5 ml. of 10 per cent. sulphuric acid for two minutes to hydrolyse any glycosides. Filter while hot; cool the filtrate and shake out with benzene. To the clear benzene solution add half its volume of 10 per cent. ammonia, shake and allow to separate when the ammoniacal layer will have acquired a rose-pink colour. (Fairbairn, 1942.)

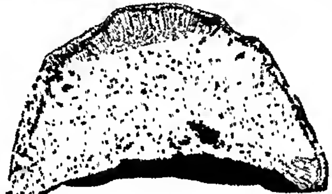
Uses. In small doses of about 1 to 8 gr. rhubarb is a bitter stomachic and intestinal astringent; in larger doses of about 15 to 45 grains it causes purgation, which is followed by an astringent effect due to the tannoid constituents. It is given in cases of indigestion with diarrhœa and as a mild laxative.

Substitutes and Adulterants. *English Rhubarb.* In England two species of *Rheum*, viz., *R. officinale* and *R. rhaponticum* Linn., are cultivated (Oxfordshire, Suffolk, etc.). The rhizomes are dried and sold separately from the roots. Those of *R. officinale* resemble the Chinese drug, but, being more spongy, shrink and wrinkle as they dry, and are softer to cut; the white reticulations are commonly absent, the white lines being parallel to one another; the star-spots are also fewer and more scattered. The

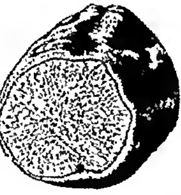
which exhibits a diffuse circle of isolated star-spots. Rhapontic rhubarb contains no emodin, aloë emodin, or rhein; its most characteristic constituent is a crystalline glycoside, rhaponticin, which fluoresces blue in ultra-violet light. Its presence can be demonstrated by the following test: Percolate 10 gm. of the powdered drug with 60 per cent. alcohol; collect

25 c.c. of the percolate, evaporate at 80° to 7 gm., shake vigorously while still warm with 10 c.c. of ether, pour off the ethereal solution into a small flask, cork and set aside; needle-shaped crystals of rhaponticin will separate within twenty-four hours. This test serves to identify the drug derived from *R. rhaponticum*, and will detect it in a mixture of 1 part of rhapontic rhubarb with 3 of Chinese, but in this case crystals *do not* separate for a few days.

Rhapontic rhubarb also contains chrysophanol, a crystalline substance chrysopontin, $C_{15}H_{14}O_{4}$, and a glycoside yielding by hydrolysis, chryso-



A



B

FIG. 139 English rhubarb (*R rhaponticum*) *A*, transverse section of rhizome. *B*, transverse section of root Natural size (After Greenish)

rhapontin, $C_{16}H_{14}O_{4}$. According to Hesse the drug contains, in addition to rhaponticin and chrysophanol, anhydrorhapontigenin, rhabarberone, chrysarone, gluco-chrysarone, gallic acid and rhapontic acid.

Chinese Rhapontic Rhubarb. This variety has latterly been imported from China; it closely resembles English rhapontic but is usually darker, often hollow in the centre, the section exhibiting alternating paler and darker concentric rings and a yellow rather than pink colour; it yields rhaponticin by the test described above.

Rhapontic rhubarb *fluoresces* bright blue in ultra-violet light and when powdered and mixed with powdered Chinese rhubarb the particles can be seen in ultra-violet light as bright blue specks in the velvety-brown

ground colour due to the Chinese drug. By using a pocket-lens to examine an adulterated powder the presence of as little as 5 per cent. of rhapontic rhubarb can be detected by this method.

Indian rhubarb is obtained from *Rheum emodi* Wallich, which grows in the Himalayas. The pieces of drug are a good deal shrunken and are soft and easily cut. In ultra-violet light it fluoresces deep violet with a certain amount also of velvety brown patches. It does not contain rhaponticin; it gives a positive reaction for anthraquinone derivatives.

Many species of *Rumex* contain anthraquinone derivatives and have been used as substitutes for rhubarb, *e.g.*, *R. alpinus* Linn., *R. obtusifolius* Linn., etc.

SUMBUL RHIZOME. Sumbul Root, Musk Root, Radix Sumbul

Sources. The botanical origin of commercial sumbul root is not definitely known. It is generally referred to *Ferula Sumbul* Hooker filius

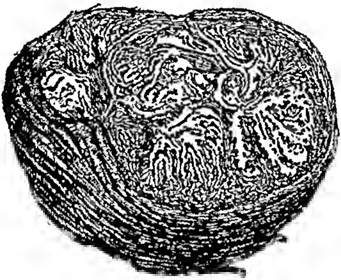


FIG. 140. Sumbul root. Slightly reduced. (*Pharmaceutical Journal.*)

family Umbelliferæ, a plant of considerable size, growing in Turkestan. This plant, however, according to Holmes, produces a large napiform root that could scarcely furnish the cylindrical pieces, 3 to 6 cm. long, that form much of the commercial drug, although it was probably the source of the original drug, which was apparently obtained from a large fragrant root. *F. suaveolens* Aitchison and Hemsley, has been suggested as yielding the commercial drug.

Description. Sumbul root occurs in short, more or less cylindrical pieces that are usually from 3 to 6 cm. in width and about the same in length, often dividing in the upper part into two, three, or more branches. The latter are occasionally not more than 1 cm. in diameter, and some of them bear a depressed scar left by the aerial stem after it has perished. The drug is spongy, fibrous and very light in weight.

The outer corky surface is dark brown to almost black and shows numerous transverse wrinkles with encircling scars of fallen leaves, often bearing short, bristly fibres which are the projecting ends of the leaf-trace bundles. The corky layer is tough and shows a tendency to exfoliate and can be peeled off almost entire. The transversely cut surface shows the thin brown external layer of cork and a very thin bark, within which is a

narrow pale yellowish ring of porous xylem bundles surrounding an abundant central parenchyma throughout which there are distributed irregular pale yellowish woody strands, the ground parenchyma being dark in colour with scattered darker shining resinous spots. The fracture is fibrous, the odour agreeable and musky and the taste bitter and slightly aromatic.

Note. Sumbul rhizome of modern commerce has not the characteristic musky odour of the older samples. It has been suggested that this modern sumbul is the product of *Ferula suaveolens* Aitch. and Hemsl.

Constituents. Very little definite information is available about the constituents of sumbul. It yields to light petroleum about 17 per cent. of a yellow viscid oil, from which crystals of an unidentified substance were obtained; about 6 per cent. of an aromatic, bitter amber-coloured resin has also been isolated; glycosidal resins present yield, on hydrolysis, umbelliferone, sucrose, levulose, etc. Free umbelliferone and traces of volatile oil are also present.

Uses. Sumbul is not much used in modern medicine. It is reputed to have stimulant and anti-spasmodic properties similar to those of valerian and is prescribed in cases of hysteria and certain nervous disorders.

PODOPHYLLUM RHIZOME. May-apple Root, Rhizoma Podophylli. Podophyllum

Sources. Podophyllum is the rhizome of *Podophyllum peltatum* Linn., family Berberidaceæ, a low-growing woodland plant indigenous to the eastern United States of America and Canada. It is obtained chiefly from plants growing wild in Virginia, North Carolina, Kentucky, Indiana and Tennessee.

Collection. The rhizomes are collected in the autumn, washed free from soil, cut into lengths of about 10 cm. and carefully dried; the slender adventitious roots are often removed.

Description. The pieces of rhizome are about 5 to 20 cm. long and are usually unbranched, occasional pieces show branching and then often have the form of a Y. The rhizome is sub-cylindrical with enlargements at intervals of about 6 cm., the cylindrical parts being about 5 mm. in diameter and the enlargements up to 15 mm. thick. The surface is dark reddish-brown and nearly smooth except at the enlargements which have on the upper surface a circular concave stem-scar, about 5 to 6 mm. in diameter, and on the sides and under-surface about twelve small circular root-scars, each about 1·5 to 2 mm. in diameter. The stem-scar is surrounded by a few concentric leaf-scars, which sometimes have a small bud in the axil; occasional scale-leaves are present on the cylindrical portions of the rhizome. A short piece of aerial stem is sometimes attached to the enlargements. The transversely cut surface is usually white and starchy with a circle of about twenty-five to forty small separate vascular bundles surrounding a pith, which occupies about half the diameter of the rhizome. The fracture is short and starchy, but in some specimens it may be yellowish and horny. The drug has a slight characteristic odour and a bitter and acrid taste.

Histology. Externally is a dead epidermis, excepting for those small regions showing scars left by the fall of stems, leaves and roots, where the

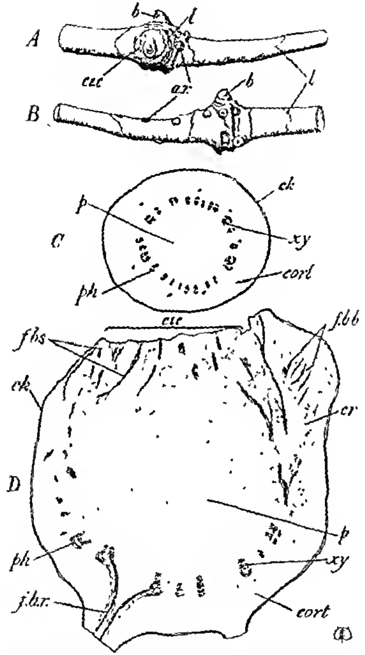


FIG. 141. Rhizome of *Podophyllum peltatum* Linn. *A* and *B*, upper and lower surfaces respectively of a piece of podophyllum rhizome, natural size. *C*, transverse section through the narrow connecting portion of a rhizome × 5. *D*, transverse section through one of the enlarged regions *carrying the scar left by the aerial stem* × 5. *a r*, *adventitious root*; *b*, bud of a lateral branch; *cic*, scar of the aerial stem; *ck*, cork; *cort*, cortex, *cr*, calcium oxalate crystal; *f.b.b.*, fibro-vascular bundles entering a branch; *f.b r.*, fibro-vascular bundles entering a root, *f.b.s.*, fibro-vascular bundles entering the aerial stem, *l*, scale leaf; *p*, pith; *ph*, phloem, *xy*, xylem.

covering consists of thin-walled cork. The *epidermis* consists mostly of elongated rectangular tabular cells, about 100 to 470µ long and 15 to 45µ wide, and a small amount of isodiametric cells about 20 to 140µ long by 15 to 45µ wide; all these cells have red-brown contents. Beneath the epidermis there is usually a single layer of cork cells. The abundant ground-tissue consists of fairly thin-walled pitted, cellulosic parenchyma with a small amount of collenchyma in the outer cortex; most of the cells contain starch grains which are sometimes simple but usually two- to four- or rarely up to forty-compound, individual grains being 2 to 15 to 30µ in width. Certain cells in the ground tissue, especially in the enlarged regions, contain cluster crystals of calcium oxalate, 20 to 100µ in diameter and often over 60µ. Small groups of pericyclic fibres occur outside some of the vascular bundles, which are small, collateral and are separated by fairly wide medullary rays. A few sub-cylindrical, narrow stone-cells occur in the pith on the inner side of certain of the vascular bundles.

Constituents. Podophyllum contains two purgative substances, podophyllotoxin, which is crystalline, and a resin, podophylloresin. The drug also contains quercetin, a yellow flavonol derivative, and much starch; it yields from 3 to 5 per cent. of ash.

Podophyllotoxin *yields by treatment with alkalies, unstable* gelatinous podophyllic acid, which easily loses water and becomes crystalline picropodophyllin, an isomer of podophyllotoxin.

Podophyllin is a resinous precipitate formed by pouring an alcoholic tincture of podophyllum into 10 vols. of acidulated water, it is a mixture of the constituents of podophyllum. If 0·4 gm. of podophyllin is added to 3 mils of 60 per cent. alcohol and then 0 5 mil. of N/1 potassium hydroxide and gently shaken, podophyllin from *P. peltatum* does not gelatinise, while that from *P. emodi*, Indian podophyllum, does.

Rhizome of *P. peltatum* in small pieces or in powder can be distinguished from that of *P. emodi* by macerating 0·25 gm. for ten minutes in 5 mils. of alcohol, 90 per cent., filtering and adding to the filtrate 0·5 mil. of a 5 per cent aqueous solution of copper acetate when a bright green colour is produced with *P. peltatum*, but a brown precipitate with *P. emodi*. (Wallis and Goldberg, 1931.)

Uses. Podophyllum rhizome, or at least the podophyllin obtained from it, is a gastro-intestinal irritant. In large doses it produces inflammation of the stomach and intestines which has proved fatal. In moderate doses it is a drastic purgative with some cholagogic action, and is much used in cases of constipation from hepatic trouble.

BLOODROOT. Rhizoma Sanguinariæ

Sources. Bloodroot is the rhizome of a small woodland plant, *Sanguinaria canadensis* Linn., family Papaveraceæ. The plant is a low-growing herbaceous perennial about 15 cm. high, found in the open woodlands of the eastern United States and in Canada. The rhizome is collected in the autumn, deprived of its roots and dried.

Description. The rhizome occurs in sub-cylindrical, straight or slightly curved pieces, about 3 to 10 cm. long and 5 to 15 mm. thick, many pieces are somewhat flattened dorsiventrally. Short lateral branches occur on some pieces; roots, when present, are small, brittle and wiry. The outer surface of the flat side is dark earthy grey to dark reddish-brown and the lower surface bears numerous small root-scars. The transversely cut

surface may be white and starchy with numerous small red points, where the laticiferous vessels have been cut across; near the periphery is a circle of about thirty small vascular bundles. Sometimes the transverse surface is uniformly blood-red and hard and resinous owing to the escape of the red latex into the other tissues of the rhizome. The fracture is short; the drug has little odour, but an unpleasantly bitter and acrid taste.

Constituents. Bloodroot contains five alkaloids, a red resin and abundant starch. The alkaloids are sanguinarine, which is crystalline and colourless, but yields deep red crystalline salts; chelerythrine, which is colourless and yields bright yellow salts; protopine, found also in opium; β- and γ-chelidonine, which are colourless.

Uses. Bloodroot in full doses depresses the action of the heart, and produces nausea and vomiting; in smaller doses it increases the appetite and improves digestion. It has been used in atonic dyspepsia, croup, bronchitis and asthma. The powdered rhizome is a powerful irritant of the respiratory passages.

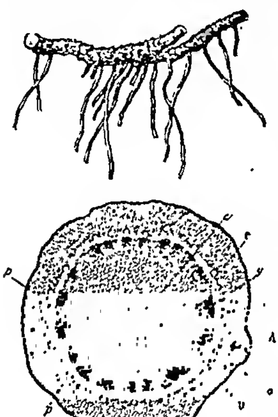


FIG. 142. *Arnica montana.* Upper figure: Arnica rhizome. Natural size. (Holmes.) Lower figure: Transverse section of rhizome. *v*, bast; *o*, primary cortex; *y*, wood-bundles; *r*, medullary *rays*; *c*, pith; *p*, oleo-resin ducts. × 10. (Berg.)

ARNICA RHIZOME. Arnica Root, Rhizoma Arnicæ

Sources. Arnica rhizome, or arnica root as the drug is commonly termed, consists of the rhizome and roots of *Arnica montana* Linn., family Compositæ, a small plant with a creeping perennial rhizome, indigenous to Central Europe, and common in the meadows on the lower mountain spurs. It should be collected in the autumn, after the aerial parts have died down, and dried.

Description. The rhizome, which is horizontal or oblique, is slender, nearly cylindrical and often slightly curved, about 5 cm. in length and about 5 mm. in thickness, and varies in colour from yellowish-brown to nearly black. From the sides and under surface numerous dark, brittle,

the scars

scars of

addition

and often

plant has

mated, is

its under

pearance.

The fracture is short and the interior is often discoloured.

The smoothed transverse surface shows externally a thin layer of brown cork; a fairly wide whitish cortex in the inner layers of which is a circle of darker oleo-resin ducts; a circle of about twenty vascular bundles having a yellowish xylem and separated by fairly wide medullary rays; and a large whitish central pith.

The drug has a faint but rather agreeable apple-like odour and a bitter acrid taste.

Constituents. Arnica rhizome contains about 0·5 per cent. of volatile [illegible] yellow and minutely [illegible] he drug yields about [illegible]

[illegible] plication for bruises, [illegible] of effused blood. It [illegible] dermatitis.

[illegible] onally present in the [illegible]

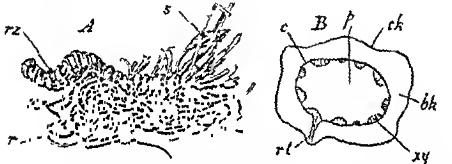


FIG. 143. Indian valerian *A*, habit sketch, natural size. (*Pharmaceutical Journ.*). *B*, transverse section × 4. *bk*, bark; *c*, cambium; *ck*, cork; *p*, pith; *r*, adventitious roots; *r.t.*, root-trace; *rz*, rhizome; *s*, stem bases.

INDIAN VALERIAN. Rhizoma Valerianæ Indicæ

[illegible]

trays supported over a wood fire.

Description. Indian valerian is a dull yellowish-brown, cylindrical rhizome, slightly flattened dorsi-ventrally and often slightly curved; it occurs in pieces about 4 to 8 cm. long and 5 to 12 mm. thick. From some samples the roots have been removed, but in others the rhizomes bear numerous wiry adventitious roots about 3 to 5 cm. long and 1 mm. thick. The surface is marked with numerous encircling leaf-scars and the sides [illegible]

[illegible] by about twelve to twenty small pale coloured xylem bundles outside which is a distinct cambium line; occasional root-traces leave the bundles

and cross the bark as paler strands. The odour and taste are similar to those of European valerian.

Const [illegible] to that [illegible] ally cor [illegible] 7 to 10 to 25 to 30 microns in diameter. Calcium oxalate is absent.

HYDRASTIS RHIZOME. Golden Seal Rhizome, Rhizoma Hydrastis

Sources. Golden seal, *Hydrastis canadensis* Linn., family *Ranunculaceæ*, is a small herbaceous plant with perennial rhizome, widely distributed in woods in Canada and the eastern United States, being collected in Ohio, Minnesota, West Ontario, Georgia, and Missouri. The rhizomes are collected in the autumn.

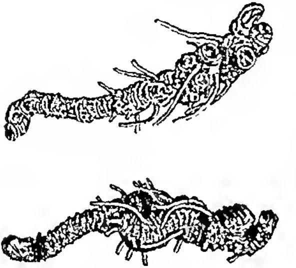


FIG. 144. Hydrastis rhizome. Natural size. (*Pharmaceutical Journal.*)

Description. The rhizome grows either horizontally or in an oblique direction in the ground; it is tortuous and sub-cylindrical, about 1 to 6 cm. long and 3 to 10 mm. thick. The surface is yellowish-brown and markedly rough from the presence of numerous remains of the slender, wiry roots, arising from all parts of the rhizome and from numerous stem-bases and scale-leaves on the upper surface. The fracture is short and resinous and the smoothed transverse surface is dark yellow to yellowish-brown and has a bark extending to about one-third of the radius, a ring of about twelve to twenty narrow, bright yellow xylem bundles, separated by fairly wide medullary rays and surrounding a pith which occupies about one-third the diameter of the rhizome. The drug has a faint, characteristic odour and a bitter taste; when it is chewed, it colours the saliva yellow.

C [illegible]

incineration

Uses. Hydrastis rhizome is a bitter tonic. It is given in chronic gastro-intestinal catarrh and nasal inflammation. It is also used as a stomachic and nervine stimulant, in menorrhagia and inflammation of the uterine mucous membrane, and is employed locally in various kinds of ulceration and hæmorrhage.

Adulterants. Accidental admixture of other rhizomes, such as those of *Aristolochia Serpentaria* Linn., family Aristolochiaceæ, *Stylophorum diphyllum* Nuttall, family Papaveraceæ, *Cypripedium parviflorum* Salisbury, family Orchidaceæ, have been observed, but they are all easily detected.

INDIAN PODOPHYLLUM RHIZOME. Rhizoma Podophylli Indici

Sources. Indian podophyllum rhizome is obtained from *Podophyllum emodi* Wallich, family Berberidaceæ, a plant growing freely on the higher slopes of the Himalayas.

Collection and Preparation. The rhizomes of plants not less than two years old are dug in the autumn; they are well washed with water, dried at first in the sun and finally spread on wire netting supported about 3 ft above a fire placed on the ground.

Description. The rhizome is tortuous, sub-cylindrical and somewhat flattened dorsiventrally; it is about 3 to 8 cm long and 7 to

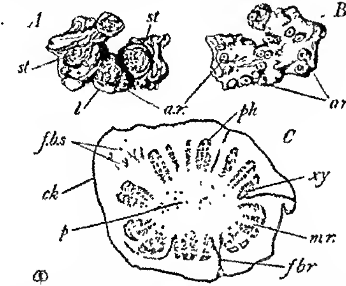


Fig 145. Rhizome of *Podophyllum Emodi* Wall. *A*, upper surface of a rhizome, natural size. *B*, under surface of a rhizome, natural size. *C*, transverse section of a rhizome × 5. *a r.*, adventitious root; *ck*, cork; *f b r*, fibro-vascular bundles entering a root, *f.b s*, fibro vascular bundles entering a stem, *l*, scale leaf; *m.r.*, medullary ray, *p*, pith with calcium oxalate crystals represented by dots; *ph*, phloem; *st*, scar left by the aerial stem

15 mm thick; numerous plump cylindrical roots, about 2 to 3 mm. thick, are present on the sides and undersurface or their circular scars only may be present, the brittle roots having been broken off and occurring in large numbers loose to the extent of as much as 75 per cent. of the drug. The surface is yellowish-brown and has on the upper side about three to five circular or elliptical stem-scars which are closely arranged and are about 5 to 8 mm. in diameter, each having several bundle traces. The fracture is short and the broken surface is starchy or horny. The smoothed transverse surface shows a ring of nine to eighteen vascular bundles surrounding a large pith, which occupies about one-third of the diameter of the rhizome, the cortex is narrow and externally there is a thin brown cork. The odour is slight and characteristic; the taste is bitter and acrid. Dust from the powder is very irritating to the eyes

Histology. The *rhizome* is covered externally by about six layers of tabular, thin-walled, polygonal cork cells; the ground tissue consists of a stout-walled cellulosic parenchyma with simple pits and containing starch grains which are usually two- to four-, rarely up to twenty-compound, the individual grains being usually 2 to 7 microns and rarely up to 35 microns in diameter, so that generally they are smaller than those of *P. peltatum*. Cluster crystals of calcium oxalate occur in the parenchyma and mostly measure about 20 to 30 microns, sometimes being larger, but never over 60 microns—another distinction from *P. peltatum*. On the inner side of the vascular bundles there are perimedullary groups of short and contorted sclereids; the elements of the xylem vessels also are often rather short and irregular in shape. The *roots* have a slightly papillose epiblema with strongly thickened outer and anticlinal walls; the cortex is wide and the cells contain starch similar to that of the rhizome, but calcium oxalate is absent; both exodermis and endodermis are suberised and have wavy longitudinal walls; the stele is four- to nine-arch and there is usually a pith composed largely of a central group of pitted sclereids.

Constituents. The constituents also are similar to those of the American drug, but the yield of resin is usually higher (10 to 12 per cent.) and the amount of podophyllotoxin greater (1 to 4 per cent.), the resin containing approximately twice as much podophyllotoxin as the resin from the American drug, and being about twice as active. The two resins may be distinguished by the following test due to Dott: Mix 0·5 gm. with 15 c.c. of 10 per cent. solution of ammonia and 15 c.c. of water; stir well for fifteen minutes, filter, wash and dry; the insoluble residue from American podophyllin should not exceed 0·06 gm.; from Indian about three times as much will be obtained.

When 0·3 ml. of 5 per cent. aqueous copper acetate is added to the filtrate obtained after macerating 0·25 gm. of the powdered drug for ten minutes in 5 ml. of alcohol, 90 per cent., a brown precipitate is formed. This reaction appears to be due to the tannin in the rhizome and distinguishes it from *P. peltatum*.

SERPENTARY RHIZOME. Serpentary Root, Virginian Snakeroot, Rhizoma Serpentariæ

Sources. *Virginian snakeroot* is the dried rhizome and roots of *Aristolochia Serpentaria* Linn., family Aristolochiaceæ, a small herbaceous perennial with a slender rhizome, growing in the United States, to the east of the Mississippi.

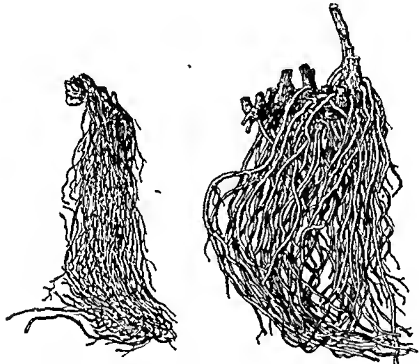
Texan or *Red River snakeroot* is obtained from *Aristolochia reticulata* Nuttall, a rather stouter plant, growing in the south-western States.

... the autumn and dried. The drug was
... use having been learnt from the
... place in the London Pharmacopœia
of 1650.

that is distinctly eccentric, being nearer to the upper than to the under surface; the xylem-bundles are numerous, yellow and curved, the ... the section of the root shows a ... white bark.

... our, a characteristic campho- ... bitter and acrid taste.

... ; a shorter ... ming little ... oil (about



A B

FIG. 146. Serpentary rhizome. *A*, Virginian. *B*, Texan Natural size. (*Pharmaceutical Journal.*)

1 per cent.), tannin, and a bitter principle, apparently an alkaloid, ... identical with the

Uses. Serpentary possesses local and general stimulant and tonic properties closely resembling those of valerian and cascarilla. It is occasionally used in nervous, despondent, and excitable conditions, as well as in low fevers and febrile states.

LIQUORICE ROOT. Radix Glycyrrhizæ

Sources. ... species of ... cultivated

Spain, from which countries the largest supplies are derived; it is also grown in Anatolia. *G. glandulifera* Wald. and Kit. grows extensively in Russia, chiefly in the basin of the Volga and yields large quantities of Russian liquorice. *G. violacea* is grown in Persia, chiefly in the valleys of the Tigris and Euphrates; it is the source of Persian liquorice.

Cultivation and Collection. *Glycyrrhiza glabra* requires a deep rich loam, carefully prepared and well manured with farmyard manure. Old heads of liquorice are divided into pieces, each having two or three buds of aerial shoots. These sets are planted out in March at intervals of about 2 ft. in rows about 3 ft. apart. The crop is manured during the growth of the green parts and, when the stems have died down in the autumn, they are cut off level with the soil which is well worked over between the plants. The field is covered with manure, which is dug in during the following March. In October of the third year, when the leaves fall, the plants are dug up, buds and rootlets are removed and the roots and stolons are dried rapidly in the sun and finally in a heated chamber.

The drug from Spain and Sicily is exported in bales or in bundles of straight cylindrical pieces. It is marketed both in the unpeeled and in the peeled condition.

Description. *Unpeeled Spanish liquorice* consists chiefly of stolon with a few pieces of root; the pieces are unbranched and may be as long as 1 metre and are from 1 to 2 cm. in diameter. Frequently the drug is cut into lengths of about 20 cm. and bound into bundles with wire. The outer surface is dark reddish-brown, longitudinally wrinkled and the stolon bears occasional small buds, scale-leaves and scars of slender side roots. The smoothed transverse surface of the *stolon* shows a thin, brown cork externally, a well-marked cambium line and a central whitish pith; beneath the cork there may be a very narrow cortex or phelloderm about 0·1 mm. wide; the stele has a radiate structure with about 70 to 100 pale-coloured medullary rays between radiating lines each consisting of a yellow xylem with vessels and groups of xylem fibres within the cambium and a yellowish-grey phloem with groups of phloem fibres alternating with sieve tissue [illegible] The structure of the pieces [illegible] pith is absent and there are [illegible] llary rays leading from the centre to the cork.

The fracture is fibrous in the bark and splintery in the wood. The *odour is faint and characteristic and the taste is sweet, without any* marked bitterness or acridity.

Peeled liquorice has a pale yellow, slightly fibrous exterior, which often shows longitudinal flattish areas resulting from the use of a knife for peeling.

Powdered liquorice is usually made from the peeled root, which gives a product of superior colour and taste.

Histology. *Stolon.* The cork consists of several radially arranged rows of thin-walled, polygonal, tabular cells, beneath which there may be a few rows of parenchyma forming the cortex; the parenchymatous pericycle has small groups of fibres at intervals; the rays of phloem consist of groups of yellowish and slightly lignified thick-walled fibres alternating with sieve-tissue, which in the outer part has collapsed to form ceratenchyma,

the sieve-tissue adjacent to the cambium being the only part which shows clearly the sieve-tubes and phloem ...
consist of groups of x ...
strongly lignified, and ...
with a little xylem ...
covered with bordere ... openings; the fibres of both phloem and xylem are in bundles of about ten to fifty fibres, individual fibres having a diameter up to about 20μ; the medullary rays are composed of cellulosic parenchyma, the rectangular cells being somewhat elongated radially. Many of the parenchymatous cells, occurring in longitudinal

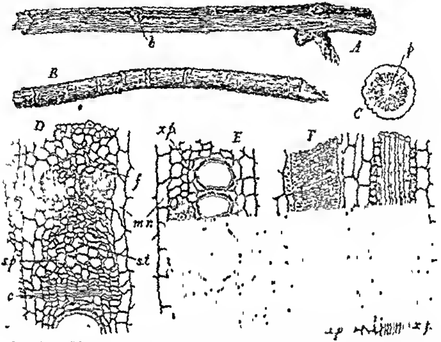


FIG. 147. Liquorice, *Glycyrrhiza glabra*. A, a stolon × ½. B, a root × ½. C, transverse section of a stolon × 1. D, transverse section of the phloem × 130. E, transverse section of the xylem × 130. F, radial longitudinal section of the xylem × 130. *b*, bud; *c*, cambium; *f*, phloem fibres, *m r*, medullary ray; *p*, pith; *s.p*, sieve-plate; *s t*, sieve-tube; *v*, vessel; *xf*, xylem fibres, *xp*, xylem parenchyma (*A, B* and *C* from *Pharmaceutical Journal*, *D, E* and *F* after B. Gram.)

rows adjacent to the fibres of both ...
and each ...
to ...
ox ...
2 ...

th ...
at right angles ...
wards; there ...
d ...
o ...

rc ... grows wild on the
b ... needing no cultivation. The plant

that yields this root is *G. glandulifera* Waldstein and Kitaibel (= *G. glabra* var. *γ-glandulifera* Regel and Herder). Instead of producing numerous runners this plant forms a large rootstock, from which long perennial roots are given off. These are usually freed from the purplish-brown cork by scraping.

Nearly all the Russian liquorice root that reaches this country has been peeled, and presents therefore a smooth yellow exterior, to which loose fibres are attached, the larger pieces being often longitudinally split. It attains a much larger size than the root of *G. glabra*, the crown of the root, which shows the remains of several stems, being occasionally as much as 10 cm. in diameter. The texture is commonly looser and more fibrous, [illegible]

It consists, however, chiefly of roots; their colour is purplish rather than brown, and the cork is often scaly.

Persian Liquorice Root. Liquorice root is also largely collected in the valleys of the Tigris and Euphrates from *G. violacea* Boiss. (= *G. glabra* var. *β violacea*) and exported in bales from Bussorah. It is usually unpeeled [illegible]

G. glabra. Some of the pieces of Anatolian liquorice root are of very large size, up to 5 or 8 cm. in diameter.

Constituents. The principal constituent of liquorice root is the sweet principle, glycyrrhizin, which, when quite pure, is a white, crystalline, intensely sweet powder, soluble in water. This has been shown to consist of the potassium and calcium salts of glycyrrhizinic acid, a colourless, crystalline acid, slightly soluble in water, but imparting a sweet taste to it in a dilution of 1 in 20,000; it is not a glycoside, as was formerly supposed, since it yields on hydrolysis glycyrrhetinic acid and glyconic acid, but no sugar. Liquorice root contains about 5 to 7 per cent. of it. The drug also contains glucose (1·4 per cent.), sucrose (2·5 per cent.), starch (29 per cent.), an acrid bitter principle, proteins, asparagin, fat, and resin. It yields from 3 to 4 per cent. of ash (peeled drug), and from 15 to 27 per cent. of aqueous extract dried at 100°, good samples yielding not less than 20 per cent.

Glycyrrhizin is related to the saponins; it has no hæmolytic action, but its decomposition product, glycyrrhetinic acid, has; Kobert considers that this explains the value of liquorice as an expectorant.

Uses. Liquorice root is a demulcent and expectorant; the liquid extract is often employed to mask the taste of nauseous medicines.

Adulterants, etc. *Manchurian Liquorice root*, possibly derived from *G. uralensis* Fischer, may be distinguished by the following characters: The cork is pale chocolate-brown and exfoliates readily; the wood is easier to cut and exhibits lacunæ; the medullary rays are conspicuously curved or wavy. It contains an average percentage of glycyrrhizin, but not more than traces of sugar (Fahmy, 1923).

Many other plants are remarkable for their sweet taste, but the presence [illegible] proved only in *Periandra dulcis* Martius [illegible] *Pradosia lateseens* Radlkofer (Monesia [illegible] The root of *Abrus precatorius* Linn.

(Indian liquorice, family Leguminosæ), *Trifolium alpinum*, Linn. (mountain liquorice, family Leguminosæ, Europe), *Astragalus Glycyphyllos* Linn. (family Leguminosæ), *Polypodium vulgare* Linn. (family Polypodiaceæ), *Myrrhis odorata* Scopoli (family Umbelliferæ), *Ononis spinosa* Linn. (family Leguminosæ), etc., contain sweet principles, possibly glycyrrhizin. The leaves of *Eupatorium Rebaudianum* (family Compositæ) contain eupatorin and rebaudin, said to be 180 times as sweet as sugar. According to Kobert eupatorin is a neutral and rebaudin an acid saponin.

Note. *Stick Liquorice.* The manufacture of stick or block liquorice is carried on chiefly in southern Italy, but also to some extent in Spain, Anatolia, etc. The runners and roots of both wild and cultivated plants are collected, crushed, boiled with water, and pressed. The decoction thus obtained is allowed to clear by standing, and is then run off into large pans, where it is concentrated by boiling until it has acquired a suitable consistence, when it is formed into sticks which are stamped with the name of the manufacturer (*e.g.*, Solazzi), or blocks (largely Anatolian) and dried.

Stick liquorice contains approximately 10 to 13 per cent. of glycyrrhizin, 13 per cent. of sugars, 23 per cent. of starch and gum, and 22 per cent. insoluble in water.

GELSEMIUM RHIZOME. Yellow Jasmine Root, Radix Gelsemii

Sources, etc. Yellow jasmine consists of the dried rhizomes and roots of *Gelsemium nitidum* Michaux (*G. sempervirens* Aiton), family Loganiaceæ, a climbing plant indigenous to the southern United States; it ascends lofty trees, and forms festoons, scenting the atmosphere with its fragrant yellow flowers. It has long been known, but its medicinal use is of recent date. The rhizome and roots should be collected in the autumn.

This plant should not be confused with *Jasminum nudiflorum* Lindley, a yellow-flowering jasmine cultivated in this country.

Description. The drug consists of the rhizomes, to which portions of small and large roots, and sometimes of slender aerial stems, are attached; usually the rhizomes and larger roots, cut into pieces about 15 cm. in length, constitute the commercial drug.

The rhizomes are generally in nearly straight, cylindrical pieces varying from 5 to about 20 mm. in thickness, of a dark purplish-brown colour, or at least marked with a more or less distinct network of purplish lines, the intervening spaces being yellowish-brown. This difference in colour is due to the fact that the outer cork cells are filled with a dark reddish-brown substance, the inner with a yellowish; by the growth of the rhizome the outer dark layer is fissured, disclosing the paler inner layer. The rhizomes are hard, woody, and difficult to break, the fracture being irregular and splintery, frequently exhibiting in the phloem silky fibres, which, however, are much more conspicuous in the aerial stems.

The roots are, on the average, rather smaller than the rhizomes; they may be distinguished by their uniform yellowish-brown colour, finely wrinkled surface, and rather more sinuous form.

The aerial stems are usually slender, but may attain 15 mm. in thickness. They are of a dark purplish-brown colour, longitudinally wrinkled or nearly smooth, internally whitish and hollow in the centre. The fractured bark exhibits projecting strands of sclerenchymatous fibres.

Both rhizome and root exhibit in transverse section a comparatively narrow bark enclosing a large, yellowish-white finely radiate wood; the latter consists of narrow xylem-bundles with small vessels alternating with distinct, straight, whitish medullary rays. The section of the rhizome is distinguished from that of the root by the presence of a small pith, which, however, is more evident in the smaller (younger) than in the larger

(older) pieces; it differs also from that of the aerial stem in the arrangement of the fibres in the bark; in the stem these are grouped into bundles, whilst in the rhizome they form an interrupted ring of isolated fibres or groups of two or three (Sayre, 1897).

The drug has a bitter taste, especially conspicuous in the bark, and a very slight aromatic odour.

Constituents. Gelsemium rhizome contains three crystalline alkaloids, gelsemine, $C_{20}H_{22}O_2N_2$, sempervirine, $C_{19}H_{16}N_2$, and gelsemicine, $C_{20}H_{25}O_4N_2$ (Forsyth, Marrian and Stevens, 1945). Other constituents are β-methylæsculetin, emodin monomethyl ether, phytosterol, resin and fixed oil.

Gelsemine must be carefully distinguished from gelsemin, which is a powdered alcoholic extract.

Uses. Gelsemium resembles hemlock in action but is more strongly depressant. It has been much used for, and appears to relieve, certain forms of neuralgia and sick headache as well as rheumatic and ovarian pains.

Substitutes. The rhizome of *Jasminum fruticans* Linn., is said to be collected in the place of gelsemium. It may be distinguished by the cells of the pith, which are thin-walled and full of starch, while those of gelsemium are thick-walled and empty.

TURMERIC. Rhizoma Curcumæ

Sources, etc. Turmeric consists of the prepared rhizomes of *Curcuma domestica* Linn., family Zingiberaceæ, a native of southern Asia, though no longer known in the wild state. It is cultivated in India, China, Java, and other tropical countries. The rhizome has long been employed both as a spice and as a colouring agent (*Crocus indicus*). It was known to Dioscorides, and described by ... a yellow colour and bitter taste ... and is now considered inferior ... largely employed as a dye and as a condiment.

Collection and Preparation. The rhizomes are dug up after the herbaceous aerial stems have died down; there is then found an upright, bulb-shaped rhizome, from which the stem has sprung and to which several cylindrical descending branches are attached. One or more of the latter, destined to produce aerial stems in the following year, will curve upwards and ... obtained are then ... which ... they are finally dried either in the sun or in an oven, and (sometimes) sorted into "fingers" and "bulbs," the former being the cylindrical descending branches, the latter the erect, stem-producing ones.

Description. *Finger or long turmeric* occurs in curved or nearly straight cylindrical pieces bluntly tapering at each end. The outer surface is of a deep yellowish-brown colour, longitudinally wrinkled and marked with transverse rings (leaf-scars). Occasionally they bear short knob-like ... where these have been broken off. ... internally they ... and tough horny consistence. The smoothed transverse surface exhibits a paler (or sometimes darker) ring separating the stele from the cortex. This appearance of the interior of the rhizomes is due to the prolonged boiling they undergo, by wh... only is the starch gelatinised, but the colouring matter, ... in scattered cells, becomes uniformly diffused th...

Bulb or round turmeric resembles the finger variety, but is, as its name indicates, shorter and thicker

The drug has a characteristic aromatic odour and taste, and when chewed colours the saliva yellow.

Constituents. Turmeric contains about 5 per cent. of volatile oil, resin, and a crystalline yellow body, curcumin. These occur, in the fresh rhizome, in the particular secreting cells in which they have been produced, but pass during the scalding into the surrounding tissue, the parenchymatous cells of which are filled with amorphous masses of gelatinised starch.

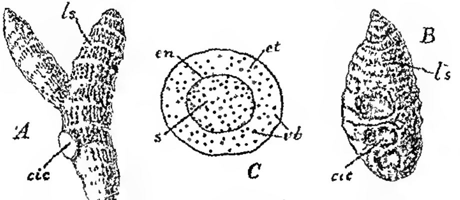


Fig 148. Madras turmeric. *A*, long turmeric. *B*, bulb turmeric. *C*, transverse section × 2 cic, scar left by removal of a branch; *ct*, cortex; *en*, endodermis, *l s*, leaf-scar, *s*, stele, *v b*, vascular bundle (*A* and *B* from the *Pharmaceutical Journal*)

Uses. Turmeric is used as a condiment and colouring agent, and as a reagent for the detection of boric acid.

Note. East Indian Arrowroot. Other species of *Curcuma* (*C. angustifolia* Roxburgh, *C. leucorhiza* Roxburgh) have paler coloured rhizomes; these are utilised in India for the production of starch, which is known as "East Indian Arrowroot."

Zedoary (*C. Zedoaria* Roscoe). India; circular slices of a rhizome resembling bulb turmeric; greyish or yellowish; starchy, section exhibiting numerous oleo-resin cells, and bundles without sclerenchymatous elements. The epidermis bears thick-walled, unicellular, sharply conical trichomes. *Taste and odour resembling ginger but less aromatic.*

GINGER. Zingiber, Rhizoma Zingiberis

Sources. Ginger consists of the rhizome of *Zingiber officinale* Roscoe, family Zingiberaceæ, divested of its roots and prepared in different ways according to the commercial variety and the country of origin. The plant, which is a native of south-eastern Asia, is cultivated in many tropical countries, notably in the West Indies, India, Nigeria and West Africa. The most highly valued kind comes from Jamaica; varieties from India and Africa are more pungent and less pleasantly aromatic in taste.

Cultivation and Collection. The soil should be a well-drained rich loam and the climate must possess an abundant rainfall or, in its absence, irrigation is necessary. In Jamaica the situation chosen is from 600 to 1,500 metres above sea-level. The plants are propagated from cuttings of the rhizomes, which are divided into small pieces, called "fingers," each of which carries a bud. The cuttings are set out at intervals of about

rhizomes are ready to be dug in the following January or February.

The plants are forked up, buds and roots are cut off, mould and dirt are removed by washing. The rhizomes are soaked over night in clean water and then the whole of the dark outer skin, consisting of cork and a little underlying parenchyma, is scraped away with a narrow-bladed knife. Removal of the buds prevents the rhizomes from growing out and the scraping, by removing the inert outer layer, yields a better product and at the same time improves the colour and hastens the process of drying. The scraped rhizomes are again washed and spread in a single layer on hurdles raised about 1 metre above the ground and are allowed to dry in the sun. The drying takes about five or six days, the rhizomes being turned several times daily. The product is known as "unbleached Jamaica ginger."

Unpeeled commercial varieties of ginger are often prepared by plunging the rhizomes for a few minutes into boiling water to destroy their vitality. Frequently the skin is removed from the flat lateral surfaces but is allowed to remain in the grooves between the branches.

Such ginger is known as "coated" or "unscraped," whilst that which has been completely peeled is called "scraped." Sometimes, too, the rhizomes are treated with sulphurous acid or chlorine, or they are dusted over with calcium sulphate or carbonate which imparts to them a whitish appearance; ginger that has been treated so is termed "bleached" or "limed" ginger. Commercial ginger may therefore vary in appearance according to the way in which it has been prepared for the market. As with nutmegs, limed ginger is undoubtedly less susceptible to the attacks of insect pests. Limed ginger is commonly washed and limed abroad, but is also usually rewashed and heavily limed in London.

Description. Unbleached Jamaica ginger occurs in branched pieces known as "races" or "hands." These pieces are from 7 to 12 cm. long and up to 6·5 cm. high; each piece consists of a horizontal rhizome from which branches, about 3 to 6 cm. long and known as "fingers," arise vertically. The branching system is sympodial and the whole piece is laterally compressed, being from 1 to 2 cm. thick. Externally the drug is pale yellowish-buff, the surface being longitudinally striated and somewhat fibrous from the projecting remains of leaf-trace bundles. The scraping has removed all traces of root-scars and there is a small circular depression at the tip of each branch, where the bud has been cut out. The fracture is short with projecting fibres and is mealy or hard and somewhat resinous. The smoothed transverse surface is elliptical with a well-marked endodermis separating the cortex, which may occupy up to one-third of the radius, from the central stele; a few root traces cross the cortex from bundles in the stele. The greyish vascular bundles are scattered throughout both cortex and stele, being smaller and more numerous near the endodermis; minute yellow points irregularly distributed in the ground tissue are the cells containing the volatile oil. The odour is agreeable and aromatic; the taste is pleasantly pungent and aromatic.

Histology. The entire ground tissue consists of cellulose parenchyma with thin-walled, rounded-polygonal cells, about 50 to 100μ in diameter; the majority of these cells contain starch grains which are flattened and oval-oblong with a terminal protuberance in which the hilum is situated,

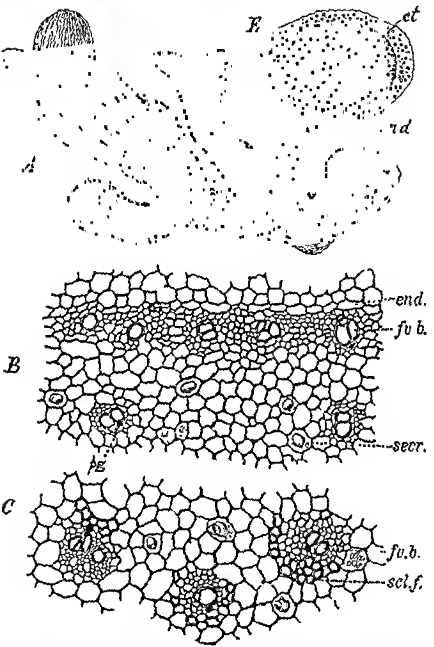


FIG. 149. Jamaica ginger, *Zingiber officinale*. *A*, hand of ginger. *B*, transverse section in the region of the endodermis × 100. *C*, transverse section of the central part × 100. *E*, transversely [illegible] rhizome, vascular bundles [illegible] × 3. *ct*, cortex; [illegible] cell; *s*, stele; *scl.f*. [illegible] Journ. *B* and *C* after Tsch[illegible]

striations run across the grains at right angles to their long axes. The starch grains are 12 to 50μ long, 20 to 30μ wide and 7 to 10μ thick; only very rarely do compound grains occur. Scattered amongst the starch-bearing cells are cells containing yellow masses of oleo-resin and having cuticularised walls. The cells of the endodermis and pericycle contain no starch and in the drug they are collapsed. The vascular bundles are collateral and, with the exception of those in the neighbourhood of the endodermis, each has associated with it a group of fibres, usually arc-shaped and sometimes nearly surrounding the bundle. The xylem vessels are annular, spiral or reticulate, the thickenings being unlignified; the fibres are rather thin-walled and are unlignified excepting the middle lamella, they are up to 60μ wide and 1 to 1·5 mm. long and often have delicate pectosic transverse septa. Accompanying many of the vessels is a slender elongated cell, containing brown pigment. Calcium oxalate and

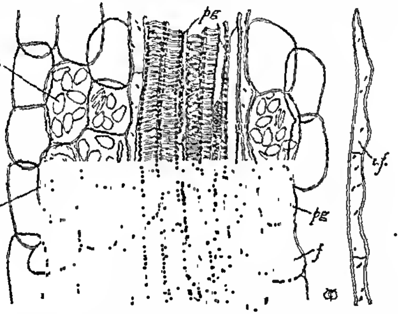


FIG. 150. Jamaica ginger, *Zingiber officinale*, longitudinal section. *a*, starch; *f*, fibre; *i.f.*, isolated fibre showing segmentation; *o.r.*, oleo-resin; *pg*, pigment cell. × 200.

sclereids are absent. Unbleached Jamaica ginger is free from cork, but in the "unscraped" varieties a cork composed of thin-walled polygonal compressed tabular cells is present.

Constituents. [illegible] of a volatile [illegible]. The latter [illegible] is odourless, but has an intensely pungent tasto. The drug contains in addition resin and about 56 per cent. of starch. It yields from 2·4 to 5·4 per cent. of ash and 1·8 to 3·4 per cent. of ash soluble in cold water.

The pungency of gingerol is destroyed by boiling with 2 per cent. solution of potassium hydroxide, while that of capsaicin or paradol is scarcely affected.

Jamaica ginger yields to cold water 19 to 20 per cent. of extractive and African ginger yields 13 to 15 per cent.; for genuine ginger the value should not fall below 12 per cent., but a standard often used is 10 per cent.

Varieties. *Cochin Ginger* occurs in both the scraped and coated varieties; the latter bears on its ventral and dorsal surfaces, but not on the lateral, portions of a reddish-grey cork, coarsely wrinkled both longitudinally and transversely. The lateral surfaces, that have been freed from the cork, are striated and of a rather paler colour. The drug is usually in smaller "hands" than the Jamaica, the branches ("fingers") are commonly shorter and thicker, and the aroma less agreeable.

African Ginger. Much African ginger is coated, the ventral and dorsal surfaces bearing patches of wrinkled cork of an earthy-brown colour. The cortical tissue that is exposed on the lateral surfaces is sometimes of a dingy grey colour and lighter than the cork, sometimes nearly black and then much darker. The drug in bulk is darker than Cochin ginger and appears discoloured from want of care in preparation.

Ginger now cultivated in Sierra Leone and in Nigeria is grown from plants originally imported from Jamaica. This drug is carefully prepared and is similar to the unbleached Jamaican variety, but is less pleasantly pungent.

Indian or Bengal Ginger is sometimes dark and partly coated, resembling

FIG 151. *A*, Cochin ginger (from *Pharm. Journ.*). *B*, African ginger. Both × ½.

African. Much is now carefully scraped and dried and resembles Jamaican in appearance; its pungency is more fiery.

Ratoon Ginger is small, dull, dingy, greyish-brown, and bears evidence of having been imperfectly peeled and carelessly cured. It is of inferior aroma and pungency. It is an inferior grade of Jamaican ginger and is obtained by allowing a part of a "hand" to remain in the ground after the first crop has been collected and to grow without further attention.

Of all the commercial varieties of ginger, Jamaica is the most aromatic and African the most pungent.

Uses. Ginger is largely used as a condiment, and medicinally as a carminative and aromatic stimulant.

Adulterants. *Japanese ginger* usually occurs in small flattened unscraped pieces; it is not produced by *Z. officinale*, as many of the starch grains are compound and the volatile oil differs in physical properties from that of Jamaica ginger; it has been referred to *Z. Mioga* Roscoe.

Exhausted ginger, which is generally in the form of powder, possesses unaltered starch and the structural details are also unchanged by the process of extraction; it is therefore impossible to detect this adulterant by the use of the structural characters of the powder. The extraction process, however, modifies the solubility of the ash and also reduces the amount yielded to solvents, such as water and alcohol, according to the type of solvent used for the commercial extraction (see above under Constituents). Extraction of ginger by water will reduce the water-soluble ash by 70 to 93 per cent. of its original amount.

GALANGAL RHIZOME. Lesser Galangal, Rhizoma Galangæ

Sources, etc. Galangal rhizome is obtained from *Alpinia officinārum* Hance, family Zingiberaceæ, a reedlike plant, attaining about a metre in height, a native of and cultivated on the island of Hainan and the neighbouring south-east coast of China. The rhizome is dug up in the autumn, washed, trimmed, cut into pieces, and dried; during the latter process the pale colour of the fresh rhizome turns to a reddish-brown. The drug is exported in bales made of split cane, plaited, and bound round with cane.

Description. The drug consists of a branched rhizome, about 12 mm. thick, in pieces about 5 or 10 cm. long. These are frequently cylindrical, [illegible] leaves. Here and there the broken upper end of a root remains attached to the rhizome. It is hard, tough, and difficult to break.

FIG. 152. Galangal rhizome. Natural size. (After Greenish.)

The interior of the drug has a reddish-brown colour. The smoothed transverse surface exhibits a stele, occupying about one-third of the diameter, and a wide cortex. In both of these regions paler fibro-vascular bundles and numerous, deep red, resin-cells may be distinguished. The drug has an agreeable, spicy odour and a strongly pungent spicy taste.

Constituents. Galangal rhizome contains a little volatile oil (cineol, methyl cinnamate), and a pungent oily body, galangol. It also contains three tasteless, yellow crystalline substances, viz., kæmpferide, galangin, and the monomethyl ether of galangin.

[illegible] pungent.

ORRIS RHIZOME. Orris Root, Rhizoma Iridis

Sources, etc. Orris rhizome, or root as the drug is commonly termed,

is derived from three species of *Iris*, family Iridaceæ, all of which are cultivated for that purpose, viz.:—

Iris germanica Linn., a handsome plant with dark blue or purplish-blue flowers, distributed over central and southern Europe, extending to Africa and India, and a common garden plant in England. It is cultivated in Italy, especially in the neighbourhood of Florence and Verona, and also in Morocco.

Iris pallida Lamarck, with pale bluish flowers, a native of the eastern Mediterranean countries; it is also cultivated in Italy, and yields with *I. germanica* the bulk of the drug.

Iris florentina Linn., with large white flowers, also a native of the eastern Mediterranean region, and cultivated in Italy, but not so abundantly as the other two.

The rhizomes of all three species closely resemble one another and there are no known means of distinguishing them. They are dug up in the late summer when two or three years old, trimmed and peeled Florentine rhizomes are dried in the sun on a kind of matting made of bamboo rods for about five days; they are then spread on a cool, dry, tiled floor for eight days and finally sorted by hand; Veronese rhizomes are usually strung on cords. During the slow drying the rhizomes, which in the fresh state are almost inodorous and have an acrid taste, acquire an agreeable fragrance and lose their acridity.

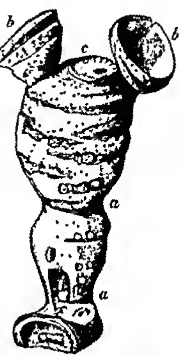


FIG. 153. Orris rhizome. Rhizome of *Iris germanica*. *a*, constrictions indicating winter growth; *b*, *b*, young branches; *c*, scar left by previous year's flowering shoot. (Tschirch, after Hartwich.)

Description. Orris rhizome occurs usually in pieces from 5 to 10 cm. long, up to 4 cm. wide and about 2 cm. thick, of a dull white colour; often dorsi-ventrally flattened and constricted at intervals or bearing one or two short lateral branches at the apex Each of the enlargements corresponds to a year's growth of the rhizome, the branches are developed from buds after the rhizome has flowered, which may not occur for three or four years. On the under surface are small dark circular scars of roots, and on the upper surface traces of the leaves, or marks of the leaf-trace bundles; the general surface shows narrow longitudinal flattish areas, separated by ridges, due to the peeling with a knife. It is hard, heavy, and compact, and breaks with a short fracture, the interior being yellowish and horny. The smoothed transverse surface exhibits a large stele containing scattered bundles and a comparatively narrow cortex, occupying about one-quarter of the radius.

The drug has an agreeable aromatic odour and a slightly bitter taste.

Constituents. By distillation with steam, orris rhizome yields about 0·1 or 0·2 per cent. of a yellowish, buttery, aromatic substance, known as oil or butter of orris; this consists principally (about 85 per cent.) of myristic acid together with irone, an oily liquid with a powerful odour of violets. Irone is the only aromatic constituent of the rhizome. The drug

also contains a crystalline glucoside, iridin, which must be carefully distinguished from the brown, resinous, eclectic remedy of the same name; the latter is obtained from the rhizome of *Iris versicolor* Linn., see below.

Varieties. *Florentine Orris Root* is usually nearly white in colour, carefully peeled, plump, and very fragrant.

Veronese Orris Root closely resembles the Florentine, but generally has a yellow colour, is rather less carefully peeled, often more wrinkled and more elongated; most of the pieces are pierced with a small hole at one end, by which they were strung during the drying.

Mogadore Orris Root is altogether inferior to both the foregoing varieties. It is in smaller, flatter, and more shrunken pieces, which often bear at their apices the shrivelled remains of numerous concentrically arranged leaves. Patches of reddish cork are left attached to the drug, which is of darker colour and inferior fragrance.

Indian Orris Root is very inferior; it is small, dark and has little fragrance; it is occasionally imported from Bombay.

Uses. Orris rhizome is used as a perfume, dentifrice, etc., although formerly medicinal qualities were attributed to it.

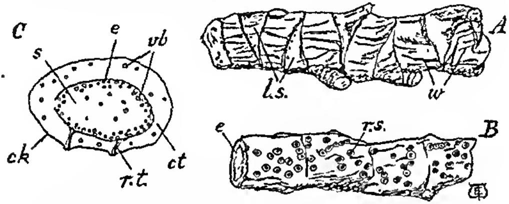


FIG. 154. Acorus calamus rhizome. *A*, upper surface of rhizome. *B*, under surface of rhizome. *C*, transversely cut surface × 2. *ck*, cork; *ct*, cortex; *e*, endodermis; *l.s.*, triangular leaf-scars; *r.t.*, root-trace; *r.s.*, root scar; *s*, stele; *v.b.*, vascular bundle; *w*, wrinkles.

[illegible] ...ed Blue Flag. It grows [illegible]

SWEET FLAG RHIZOME. Rhizoma Acori Calami

Sources. [illegible] *Calamus* Linn., family Araceæ, is a [illegible] Asia, but has become widely diffus[illegible] itself in England as a wild plant on the edges of lakes and streams. It is collected chiefly in Holland, East Prussia and Galicia.

Collection. The long, creeping, horizontal rhizome is collected in the autumn, trimmed, cut into pieces 10 cm. or more in length, and dried. Sometimes it is partially deprived of its cork by peeling or scraping; but this is inadvisable, as the peeled rhizomes yield less volatile oil than the unpeeled.

Description. The rhizome commonly occurs in pieces about 5 to 15 cm. in length and 1 to 2 cm. in thickness. They are covered with a thin brownish cork and are much shrunken, bearing deep longitudinal wrinkles.

They are marked on the upper surface with large triangular leaf-scars that encircle the rhizome, springing from each side alternately; to these scars fibrous leaf-trace bundles are sometimes attached. The under surface bears an irregular zigzag line of small raised root-scars that are circular and exhibit a central stele surrounded by a narrow cortex. Occasional pieces have a lateral branch. The scraped rhizome is of a pale brownish-buff colour, has a roughish surface, and bears less conspicuous scars of leaves and roots.

The drug breaks with a short corky fracture, and is pale brown, or nearly

bundles.

The freshly fractured drug has an agreeable aromatic odour. The taste is disagreeably bitter and pungent.

Constituents. Sweet flag rhizome contains from 1·5 to 3·5 per cent. of an aromatic volatile oil, the chief aromatic constituent of which is asaryl aldehyde. It contains also an amorphous bitter principle, acorin, yielding

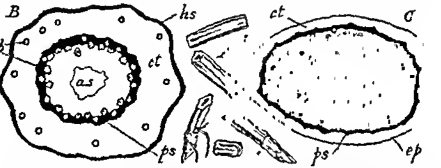


FIG. 155. Couch grass, *Agropyron repens*. *A*, pieces of chopped rhizome × 1·5 *B*, transverse section of rhizome × 15. *C*, transverse section of rhizome of *Cynodon dactylon* × 15 *a s.*, central air-space, *ct*, cortex; *ep*, epidermis, *h s.*, hypodermal sclerenchyma; *l*, lacuna; *ps*, pericyclic sclerenchyma, *v b*, vascular bundle. (*B* and *C* after Small.)

by oxidation acoretin and by treatment with acids or alkalies volatile oil and sugar The drug contains an abundance of starch and a little tannin.

Uses. The drug has stimulant and tonic properties; it has been used for ague and for atonic dyspepsia.

COUCH GRASS RHIZOME. Rhizoma Tritici, Radix Graminis, Triticum Repens

Sources. The couch grass, *Agropyron repens* Beauvais (*Triticum repens*, Linn), family Gramineæ, is abundant in this country being often a troublesome weed. It produces a slender rhizome running for a considerable distance just below the surface of the ground, giving off lateral branches, and at the nodes, which are 2 to 3 cm. apart, small fibrous roots. The rhizome is collected, cut into pieces about 1 cm. long, and dried.

Description. Couch grass usually occurs in short cylindrical pieces about 3 to 20 mm long and 2 to 3 or

surface is hard, smooth, glabrous,

yellowish-brown, and on some pieces

scars or short pieces of the slender ro

transversely cut surface shows a central hollow, excepting at the nodes,

and gives a brown colour with iodine showing an absence of starch. The

bundles is partially embedded; there are a few scattered bundles in the cortex and a hollow in the centre of the pith. The epidermis consists of longitudinally arranged rows of rectangular cells with wavy walls, each row consisting of elongated cells, which are about eleven times as long as

together about one-
ndodermis is strongly
Stomata are absent
in that of the scale-
leaves. Trichomes, crystals and starch are absent.

Constituents. Couch grass contains a carbohydrate, triticin (5 per cent.), which is not very soluble in water, and yields by hydrolysis lævulose. Mucilage, inositol and mannitol are also present. Starch is absent.

Uses. Couch grass is used as a diuretic and demulcent, especially in certain complaints of the bladder, in gout and rheumatism and in association with aperients.

Substitute. The rhizome of dog-grass or Bermuda grass, *Cynodon dactylon* Pers., is often substituted for couch grass and is easily distinguished by the presence of abundant starch and by the absence of a hypodermal band of sclerenchyma in the transverse section.

COLCHICUM CORM. Colchicum Root, Radix Colchici. Colchici Cormus

Sources. Colchicum corm is the fresh or dried corm of *Colchicum autumnale* Linn., family Liliaceæ; the plant grows throughout Europe. In England it is local in distribution, but is abundant in moist, rich meadows in certain limestone districts, notably in Gloucestershire, Herefordshire, Hampshire, Oxfordshire and Warwickshire.

Cultivation and Collection. The drug is collected chiefly from wild plants, which are often removed when a field is ploughed. The corms are often collected in June or July, at which time they are in the best condition, the leaves having withered away and the flower not yet having appeared.

Seed may be sown as soon as it is ripe, in September, in a moist shaded spot and covered thinly with soil; they germinate during the winter and early spring. When one year old the corms may be planted in the field about 60 cm. apart, and at the end of the third year they may be collected in July. Flowering usually takes place in August or early September of the fourth or fifth year. Plants may also be propagated by planting young wild corms, which should be buried at a depth of about 20 cm. They

making a juice or extract or they may be dried and stored for use as required. If they are dried, the corms are cut transversely into slices about 0·5 cm. thick and are dried at a gentle heat not exceeding 65° C.

The membranous remains of the outer scales are removed from the finished product by winnowing.

Description. The *fresh corm* is bluntly conical and flattened on one side. It is 3·5 to 4 cm. high, 2·5 to 3 cm. wide and about 2 cm. thick. [illegible] of last season's flowering stem and, running from apex to base of its surface, vascular bundles may be seen as faint lines. Scars of the fibrous roots are present at the base. Internally the corm is firm, white, and fleshy; it has a disagreeable odour, and exudes, when cut, a bitter juice that is white and milky from the presence in it of numerous starch grains.

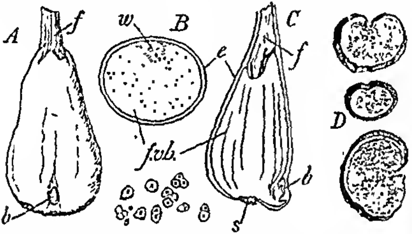


FIG. 156. Colchicum corm, *Colchicum autumnale*. *A*, flat surface of a corm gathered in June, after removal of brown outer scale. *B*, transverse section of the same. *C*, longitudinal section of the same. *D*, commercial dried slices of the corm. Starch grains at bottom of drawing × 120. *b*, bud for next season's flowering stem; *e*, brown outer envelope; *f*, remains of the flowering stem of last season; *f.v.b.*, vascular bundle; *s*, scar where corm has broken away from the parent corm; *w*, region where much shrinkage occurs during drying. (*D* from *Pharm. Journ.*)

The *dried slices* are from 2 to 5 mm. thick and about 3 cm. wide, [illegible] the transverse surface shows a white, mealy ground tissue in which are numerous scattered vascular bundles, appearing as greyish points. Pieces from the apex and base of the corm are sub-conical and plano-convex respectively. The fracture is short and starchy; the drug is inodorous and has a bitter taste.

Histology. The epidermis consists of rectangular to polygonal tabular cells, about 40 to 60 to 95μ in width or length with brown, indistinctly pitted, moderately thick walls; it contains occasional stomata, nearly circular in outline. The mass of the corm consists of a thin-walled, round-celled parenchyma filled with starch grains which are simple or

more usually compound with **two or three** or sometimes four to seven components which are *often muller-shaped*; *the hilum is central and often* a radiate split. Individual grains are **3 to 16 to** 28μ in diameter. The vascular bundles are slender, **collateral** and run longitudinally through the corm; the xylem vessels are **narrow, spiral** or **annular** and about 30μ in diameter. Colchicine is found in the epidermis and in a sheath, one cell thick, surrounding each vascular bundle.

Constituents. Dried colchicum corm contains up to about 0·6 per cent. of the toxic alkaloid colchicine. The drug also contains abundance of starch. It yields from 2·2 to 2·4 per cent. of ash.

Uses. Colchicum is chiefly used to relieve the pain and inflammation and shorten the duration of acute gout and certain gouty affections, but is liable to cause intestinal pain accompanied by vomiting and purging. Colchicine induces polyploidy in seedlings treated with a weak solution, about 0·4 per cent.

INDIAN COLCHICUM. **Colchici Indici Cormus**

Sources. Indian colchicum is the corm of *Colchicum luteum* Baker, family Liliaceæ, deprived of its membranous coats and dried.

Description. The corms are brownish and translucent or pale-buff and semi-translucent or, more rarely, opaque and cream-coloured or brownish-grey; usually ovate in outline and plano-convex with a slight contraction of the convex surface at the level of the oval scar marking the area where the corm was attached to that of the previous season and the margin of which exhibits scars left by the removal of the fibrous roots; the outer surface of the corm is marked by indefinite and irregular longitudinal striations. Some corms are broadly ovoid, about 30 to 45 mm. long, 15 to 25 mm. wide and 7 to 15 mm. thick, with a longitudinal groove 2 to 9 mm. wide, sometimes very shallow, and extending the entire length of the flat surface; the oval scar is about 3 by 5 mm., dark in colour and occurs at the base or at a position one-tenth to one-half of the length of the corm from the base. Other corms are elongated and finger-like, being [illegible]

Histology. Externally is a brown epidermis of sub-rectangular tabular cells about 58 to 80μ wide, 90 to 140μ long and 16 to 20μ high. Small scattered vascular bundles with narrow spiral vessels traverse the parenchyma which contains very abundant starch, much of which is gelatinised. The starch grains are simple and rounded or more usually compound with two to three and sometimes four components, which are muller-shaped with one or two flat facets; individual grains are 8 to 24 to 32μ in diameter; the hilum is either a point or a two- to three-radiate split.

Constituents. Indian colchicum corm contains about 0·21 to 0·25 per cent. of colchicine and an abundance of starch.

ROOTS

Classification of Roots

1. *Wide bark and a small central woody core.*
   Ipecacuanha, Dandelion.
2. *Narrow bark, large radiate xylem.*
   Alkanet, Rhatany, Senega, Derris.
3. *Narrow bark, parenchymatous xylem.*
   Calumba, Bryony, Gentian, Marshmallow, Belladonna.

4. *Large parenchymatous pith.*
   Aconite, Sarsaparilla.
5. *Large parenchymatous xylem with tertiary formations.*
   Jalap, Ipomœa.

IPECACUANHA ROOT. Radix Ipecacuanhæ, Ipecacuanha

Sources. Ipecacuanha root consists of the dried enlarged adventitious roots of *Cephaelis Ipecacuanha* (Brot.) A. Rich, family Rubiaceæ, a plant which grows in moist forests in many parts of Brazil, especially in the province of Matto Grosso, whence comes the most highly prized commercial variety. It is cultivated in Minas Geraes (eastern Brazil), and these roots have a slightly different form. The drug has been successfully produced by cultivation in Bengal, in Burmah and in the Malay Peninsula, north of Singapore (Johore).

Collection. The plant produces a slender rhizome, ascending at the tip to form an aerial stem. The rhizome bears fibrous roots, many of which become much thickened and it is these which form the commercial article.

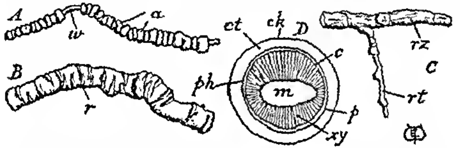


FIG. 157. Ipecacuanha. *A*, Rio ipecacuanha root. *B*, Carthagena ipecacuanha root. *C*, rhizome of Rio ipecacuanha. *D*, transverse section of *C* × 5. *a*, annulations; *c*, cambium; *ck*, cork, *ct*, cortex, *m*, pith, *p*, pericycle; *ph*, phloem; *r*, ridge; *rt*, root; *rz*, rhizome; *w*, woody cylinder denuded of bark; *xy*, xylem.

The plants grow in clumps in the woods and a group is lifted from the soil by inserting a pointed stick beneath them, the earth is shaken off and the roots are dried in the sun; any remaining adherent soil is removed by shaking the dried roots in sieves. The product is packed in bales of about 1 cwt. for export.

Description. The roots of *Matto Grosso or Rio ipecacuanha* are sub-cylindrical, slender and rather tortuous, usually 4 to 7 cm., sometimes up to 18 cm. long, and 3 to 5 mm., rarely up to 6 mm. thick; the surface is dark brown and sometimes has a brick-red appearance owing to adherent earth; they are marked by transverse constrictions or fissures which may reach as far as the wood and give an appearance of about eight annulations per centimetre; the fracture is short and starchy or horny in the bark, but splintery in the wood. The transversely cut surface shows a central core of yellowish-white dense wood, occupying about one-third of the diameter, surrounded by the cambium line and a wide greyish bark with a thin brown cork externally.

Stems, which are always present in the drug, are recognised by their slender uniformly cylindrical shape, about 1 to 2 to 3 mm in diameter, by the longitudinally striated surface, upon which scars and occasional buds may be found and by the absence of annulations. In the transversely cut surface there is a central pith, about one-sixth of the

total diameter, surrounded by a ring of dense yellowish xylem, about 0·75 mm. wide, covered externally by a narrow bark. The commercial drug often contains from 3 to 24 per cent. of stems and sometimes as much as 40 per cent., see Fig. 157.

The drug has a slight odour which, to many persons, is particularly unpleasant; the taste is slightly bitter. The powder is often very irritating to the throat and nostrils, producing violent coughing and sneezing.

Histology of Rio Ipecacuanha. At the centre of the root one may often find the triarch primary xylem well defined, especially in stained sections; surrounding this is a dense wood composed of secondary xylem traversed by medullary rays, all the elements being lignified; external to the wood is a narrow band of secondary phloem and a wide parenchymatous phelloderm, beyond which is a narrow layer of cork. The secondary xylem consists of narrow tracheidal-vessels and tracheids, both having bordered pits, associated with xylem parenchyma; the segments of the tracheidal-vessels usually have the communicating openings on the side walls near the ends; the cells of the xylem parenchyma have simple pits and some of them are developed as substitute fibres, they all contain starch grains, as also do the cells of the medullary rays. In transverse sections, [illegible]

round-celled cellulosic parenchyma filled with starch grains, excepting a few scattered idioblasts, each of which contains a bundle of acicular raphides of calcium oxalate, the crystals being about 30 to 80μ long. The starch grains are rarely single, being mostly two- to four-, sometimes up to eight-compound, individual grains measure about 4 to 10μ, but do not exceed 15μ in diameter. In powdered ipecacuanha the bundles of raphides are frequently broken and the crystals are scattered singly throughout the powder.

The cell forms present in the tissues of the *stem* resemble those of the root with the thin-walled parenchyma of the pith and the sclerenchyma of the pericycle. The pericyclic sclerenchyma consists of a single, here and there double, discontinuous layer of more or less elongated rectangular cells with thick and pitted lignified walls; these cells are about 85μ to 120μ long, 20μ to 25μ wide and 20μ thick. The number of sclerenchymatous cells present in the stem is 33 per mg., and this figure may be used to determine the proportion of stem present in powdered ipecacuanha (Lupton, 1938), see Fig. 158.

Constituents. Ipecacuanha root contains several related alkaloids, about 0·4 per cent. of a crystallisable glycoside ipecacuanhin, about 30 to 40 per cent. of starch, calcium oxalate, an acid saponin, and ipecacuanhic acid, the exact nature of which is not very clear.

The amount of total alkaloids present is about 2 to 3 per cent. The alkaloids are emetine, cephaëline, psychotrine, *O*-methylpsychotrine, and emetamine; they are closely related chemically, emetine being [illegible] The hydroxyl [illegible]

alkaloid present about 66 to 72 per cent. is emetine and 26 per cent.

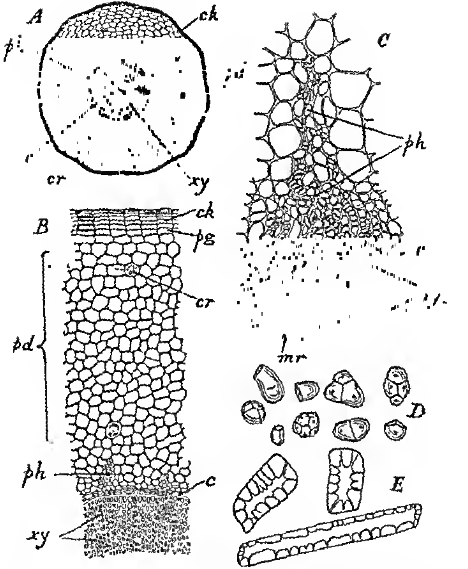


FIG. 158. Rio ipecacuanha root. *A*, transverse section × 12. *B*, transverse section of outer part of the root × 60 (starch is omitted). *C*, group of phloem, etc., × 200. *D*, starch granules × 700 *E*, sclereids from the pericycle of the stem × 200. *c*, cambium, *ck*, cork; *cr*, acicular crystals of calcium oxalate; *mr*, medullary ray; *pd*, phelloderm, *pg*, phellogen, *ph*, phloem; *xy*, xylem. (*A* after Collin, *B* and *C* after Tschirch, *D* and *E* after Greenish)

cephaëline, the cephaëline being chiefly emetic, while the expectorant

the root, but

1·5 to 2·3 per

cent. of total alkaloid.

Carthagena Ipecacuanha has been referred to *Psychotria acuminata* Karsten and is imported from Colombia. This root shows a general resemblance to Rio ipecacuanha, but is larger, being about 3 to 9 mm. in diameter. Annulations are not present, but the root is marked by transverse ridges about 0·5 to 1·0 mm. wide, which extend about halfway round the circumference of the root and fade off at their tapering extremities into the general surface; there are from one to six of these ridges per centimetre. Many of the starch grains of this ipecacuanha are larger than those of Rio ipecacuanha, individual grains measuring up to 22µ. It contains the same alkaloids as the Rio or Matto Grosso drug and in about the same amount, but the proportion of emetine is only about 30 to 40 per cent. of the total.

Nicaragua Ipecacuanha resembles a small Carthagena root. It yields 2·0 to 2·75 per cent. of total alkaloid of which 20 to 25 per cent. is emetine.

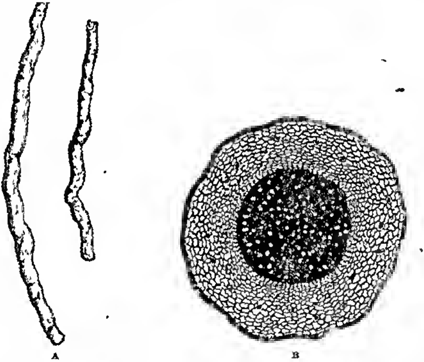


FIG. 159. Undulated ipecacuanha (*Richardsonia sp*) *A*, root, natural size *B*, transverse section × 10, showing the porous wood (Planchon and Collin.)

Minas Ipecacuanha is the produce of plants cultivated in the province of Minas Geraes; it is usually carefully cleaned and, although closely similar to the Matto Grosso variety, its surface shows the presence of some ridges like those of Carthagena ipecacuanha. Its constituents are the same as those of Matto Grosso ipecacuanha, but the proportion of emetine is about 60 per cent. of the total alkaloid.

Indian or Johore Ipecacuanha is rather larger and brighter in colour than the Matto Grosso variety which it closely resembles in structure and constituents. The proportion of emetine in the total alkaloid is about 50 per cent.; the total alkaloid present is about 2·0 per cent.

Uses. Ipecacuanha is largely used as an expectorant and emetic; it also possesses diaphoretic and cholagogue properties. One of its most important uses is as a remedy for amœbic dysentery, for which purpose large doses are given (30 to 90 grains). One part of emetine

in 100,000 has been shown to be fatal to *Entamœba histolytica*, the amœba of tropical dysentery.

Substitutes. 1. *East Indian Root.* Under this name the rhizome of a small monocotyledonous plant, probably ***Cryptocoryne spiralis*** Fischer, family

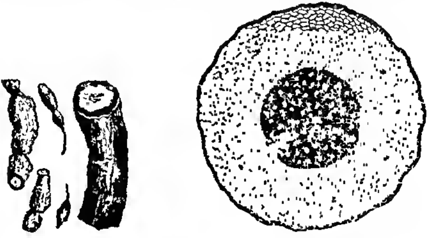


Fig. 160. Lesser striated ipecacuanha. *A*, root, natural size, cut transversely to show the dark bark. *B*, transverse section × 10, showing the porous wood. (Planchon and Collin.)

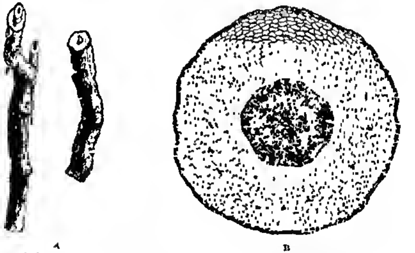


Fig. 161. Greater striated ipecacuanha (*Psychotria emetica*). *A*, root, natural size. *B*, transverse section, showing the dense wood, × 10 (Planchon and Collin.)

Araceæ, has been imported from the south of India. It occurs in short,

for instead of the central column of dense wood there is a parenchymatous stele, through which scattered bundles run; externally is a white starchy cortex.

2. *Undulated Ipecacuanha*, derived from *Richardsonia scabra* Saint Hilaire, family Rubiaceæ (Brazil), occurs in tortuous pieces, the upper part being cylindrical and bearing at the crown the remains of numerous, very slender, aerial stems. On one side of the root the bark is occasionally fissured nearly to the wood, and this gives the drug an appearance simulating the quite different regular annulations of Brazilian ipecacuanha. The transverse section exhibits a porous wood, and a thick, starchy bark often violet in colour. (See Fig. 159.)

3. *Lesser Striated Ipecacuanha.* This drug, which is occasionally found on the market, is derived from *Manettia ignita* Schumann, family Rubiaceæ; it possesses a starchy, violet (often dark violet) bark and porous wood, but is distinguished from the foregoing by its darker colour and stouter aerial stems. (See Fig. 160.)

4. *Greater Striated Ipecacuanha* is the root of *Psychotria emetica* Linn., It is about the size of Cartogena ipecacuanha and closely resembles the foregoing, being irregularly constricted, dark in colour, and exhibiting in transverse section a dark, violet-coloured bark; it may be distinguished by its dense wood, and by the presence of sugar in the bark, starch being completely absent. The colour of the bark and the absence of starch easily distinguish this root from either Brazilian or Cartogena ipecacuanha. (See Fig. 161.)

5. *White Ipecacuanha* is the root of *Hybanthus* (= *Ionidium*) *Ipecacuanha* Ventenat, family Violaceæ (Brazil). It is greyish white or yellowish in colour, 1·5 to 3 mm. thick, and frequently branches. The section exhibits a large, porous, yellowish wood and narrow, darker bark.

6. *Trinidad Ipecacuanha.* Under this name the rhizome and root of *Asclepias curassavica* Linn., family Asclepiadeæ, have been offered for sale. It is 3 to 4 mm. in diameter, yellowish brown externally and whitish internally; it bears wiry rootlets and has an unpleasant bitter taste.

The following test for emetine is useful for distinguishing roots containing that alkaloid from numerous substitutes which do not:—0·5 gm. of the finely powdered root is mixed with 20 c.c. of strong hydrochloric acid and 5 c.c. of water and filtered; to 2 c.c. of the filtrate 0·01 gm. of potassium chlorate is added; if emetine is present the liquid assumes a yellow colour, changing in the course of an hour to red.

DANDELION ROOT. Radix Taraxaci

Sources. Dandelion root consists of the fresh or dried root and vertical rhizome of *Taraxacum officinale* Wiggers, family Compositæ. The plant occurs widely distributed over Europe, Asia and North America and is a troublesome weed on arable and grass land. The roots are collected chiefly from wild plants both in Britain and in Germany. They are usually collected when the land is ploughed by following the plough and removing the roots as they are turned up. After washing free from soil, the roots are used either fresh or dried, according to the nature of the preparation to be made from them.

Description. Dandelion root consists of a simple, straight root, which, towards the upper part, passes imperceptibly into an *erect rhizome*; the latter sometuanha is ns simple, but often divides into several erect branchpossesses diaphoretich of about 30 cm., and a thickness of about 15 ust important uses is as a re is yellowish-brown externally, whitish and large doses are given (5 cut surface a bitter, milky juice—latex— is a small yellow wood.

The *dried* root is dark-brown, much shrivelled and wrinkled longitudinally; it tapers but little below, and often divides in the upper part (rhizome) into several erect branches. The rhizome and its branches are crowned with the short remains of the leaves which bear brownish hairs near the *point of insertion*. The drug breaks when dry with a short fracture, the section exhibiting a yellow, porous, central wood, occupying about one-quarter to one-third of the diameter, surrounded by a thick, whitish bark in which numerous, brownish concentric rings of sieve-tissue and laticiferous vessels are visible. The transversely cut surface of the rhizome shows a small central whitish pith, surrounded by a yellow wood outside which is a wide secondary phloem, with concentric rings as in the root, a narrow cortex, and a layer of cork externally. The drug, which is rather hygroscopic, becomes tough when slightly moist. It has no odour, but a bitter taste.

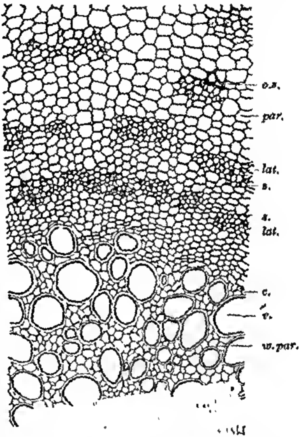


FIG. [illegible] root, transverse section. *c*, cambium; *lat*, laticiferous vessels, *o.s.*, obliterated sieve-tubes; *par.*, parenchyma of bark; *s*, sieve-tubes, *v*, vessel, *w par*, xylem parenchyma. (Tschirch)

Constituents. Dandelion root contains a small quantity of a crystalline, bitter substance taraxacin, which, according to recent researches is an indefinite mixture. The drug also contains choline, resin, the phytosterols, taraxasterol and homotaraxasterol, various fat acids, an acrid principle, and in the autumn about 40 per cent. of inulin. In the fresh root the inulin is dissolved in the *cell sap*, but in the dry root forms amorphous, transparent lumps not again readily soluble in cold water. The autumn root has been found to contain 25 per cent. of inulin, whereas the spring root contained 18 per cent. of lævulin and 17 per cent. of uncrystallisable sugar. Lævulin, $C_6N_{10}O_5$, is a soluble carbohydrate converted by hydrolysis into dextrose and lævulose.

Uses. Dandelion is a simple, bitter, and mild laxative, and is given in atonic dyspepsia attended by habitual constipation. Much dandelion root is roasted and broken into small pieces and sold as "dandelion coffee."

Substitutes. The root of a species of *Lactuca*, which has the vessels arranged in radial rows, has been substituted for dandelion root. The roasted root is often adulterated with roasted chicory.

ALKANET ROOT. **Alkanna Root, Radix Anchusæ**

Sources. Alkanet root is obtained from *Alkanna tinctoria* Tauscher, family Boraginaceæ, a small herbaceous perennial growing in sandy soil in southern Europe, Hungary, and Asiatic Turkey, our supplies being derived [illegible]

D[illegible] deep reddish-purple, simple, tapering [illegible] bout 15 cm. in length, and 12 mm. in thickness near the crown, to which slender branches and the remains of leaves are attached; the latter have a purplish colour, and bear numerous, bristly hairs. The outer layers, which are deeply coloured, easily exfoliate, separating from the wood in large, papery flakes or strips; these are readily removed, and the exterior of the root is then the inner layers of phloem tissue. It is not smooth but more or less deeply furrowed longitudinally, the furrows being often so deep as to divide the wood into separate woody strands. A transverse section of the upper part of the root exhibits a dark violet spot in the centre, and a woody ring containing several radiating strands of dense whitish woody tissue separated by large wedge-shaped masses of parenchyma; the bark is yellowish near the wood, but becomes coloured and laminated towards the exterior. From near the crown of the root downwards the violet spot in the centre becomes larger and the colouring matter in the bark penetrates deeper until by their union the separation of the strands of wood is complete. The root when handled stains the fingers red. It has no perceptible odour or taste.

Constituents. Alkanet root is said to contain two red colouring substances, viz. anchusic and alkannic acids, the former turning green with alkalies and the latter blue, but these statements require further investigation. Alkannin is the name given to an oleo-resinous mixture of deep red colour obtained by extracting the root with petroleum spirit and evaporating.

Uses. Alkanet is used for colouring oils, ointments, etc.; the tincture is used for the microscopical detection of fat and oil, which it colours red.

Varieties. Many other plants furnish roots containing a similar red colouring matter, *e.g.*, *Onosma echioides* Linn., family Boraginaceæ, from S. Europe, *Macrotŏmia Cephalōtes* de Candolle, family Boraginaceæ, from Armenia and Syria; they are occasionally substituted for the root of [illegible]

RHATANY ROOT. **Radix Krameriæ, Peruvian Rhatany**

Sources. *Peruvian rhatany* is the root of K. *triandra* Ruiz and Pavon, family Leguminosæ, which grows abundantly on the barren, sandy mountain slopes of Peru and Bolivia.

Rhatany root has apparently been used for many years by the Peruvians for cleaning and preserving the teeth. The Spaniards became acquainted with it in Lima and introduced it into Europe.

Description. The root of Peruvian rhatany is large and knotty at its upper extremity, which is about 3 to 5 cm. wide; it divides near the crown into several long stout branches, from which smaller branches proceed. The larger pieces have a dark reddish-brown colour and a rugged, scaly bark, the smaller are usually rather brighter and smoother, not exhibiting any conspicuous transverse fissures. The bark, which can easily be separated from the smaller roots, is rather fibrous, but the wood breaks with a splintery fracture. The transverse

numerous narrow medullary rays and minute vessels. The drug is quite odourless; the bark has a strongly astringent taste, but the wood is practically tasteless.

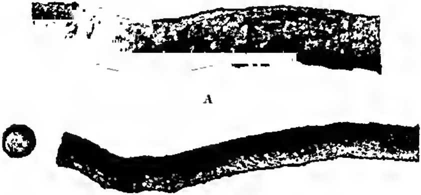


FIG. 163. Peruvian rhatany root. *A*, portion of an older root, showing scaly cork; natural size. *B*, portion of a younger root, natural size. (*After Greenish.*)

Constituents. The principal constituent of rhatany root is tannin, krameria-tannic acid, of which about 7 to 9 per cent. is stated to be present.

Peruvian rhatany yields to absolute alcohol about 23 per cent. of soluble matter. The alcoholic tincture gives a cloudy mixture with water. The root contains in addition a dark red phlobaphane, krameria-red, produced by decomposition of the tannin, as well as starch. It yields 2 to 2·5 per cent. of ash; samples of the powdered root may yield as much as 4·5 per cent. of ash.

Uses. Rhatany root is employed solely as an astringent.

FIG. 164. Pará rhatany. Natural size. (After Greenish.)

Substitutes. Several other species of *Krameria* are known to yield astringent roots, but none is now of commercial importance.

Pará rhatany is the root of *Krameria argentea* Mart., a shrubby plant growing in Brazil. The drug is shipped from [illegible]

[illegible]

of deep transverse cracks at more or less regular intervals in the bark, which is also longitudinally wrinkled. The transverse section shows a reddish wood and a dark reddish-brown bark, which occupies about one-half the radius of a root of medium size. In respect to odour and taste Pará rhatany resembles Peruvian. It yields to alcohol about 12·6 per cent.

of extractive and the tincture from Pará rhatany gives a clear mixture with water.

Indian sarsaparilla is the root of *Hemidesmus indicus* R. Br., family Asclepiadaceæ, a climbing shrub indigenous to India and Ceylon. Large pieces of Indian sarsaparilla occasionally bear a considerable resemblance to small pieces of Pará rhatany, both in colour and in the presence of transverse cracks. They may be distinguished by their agreeable odour, resembling that of coumarin, and by the difference in the transverse section, which exhibits a large, porous, but not distinctly radiate, yellowish wood, surrounded by a thin greyish or somewhat violet tinted bark.

DERRIS ROOT. Tuba Root, Touba, Aker-tuba

Sources. Derris root consists of the dried rhizome and roots of *Derris elliptica* (Roxb.) Benth. and *D. malaccensis* Prain, family Leguminosæ, tropical climbing plants indigenous to Malay, Burma, and the East Indies. The drug is cultivated in Perak and Singapore in Malay, in Sarawak in N. Borneo and in Sumatra.

Description. The *rhizome*, which constitutes a small proportion only of the drug is in short pieces about 8 to 25 mm. thick, oblique, brown, longitudinally wrinkled with numerous transverse cracks and circular lenticels. The slender *roots* form the bulk of the drug; some pieces are ... iameter is about 8 mm. ... is not more than 5 mm. ... (*D. elliptica*) or grey-brown (*D. malaccensis*) with fine longitudinal furrows. The smoothed transversely cut surface shows a thin cork beneath which is a ring of scleronchyma and a narrow brown bark, about 1 mm. wide, composed of stratified strands of phloem; the wood is yellowish and porous, the larger ... The roots are flexible, hard ... y have a slightly aromatic ... by a slight sensation of numbness in the tongue, which is very persistent and extends to the throat, where a feeling of dryness somewhat resembling the effect of aconite is experienced.

Histology. At the centre of the root is a four- or five-arch primary ...

sieve-tissue ... longitudinal files of small cells each containing a prism of calcium oxalate ... 20μ in diameter. The fibres of both xylem and phloem have about 10μ to ... middle lamella lignified. In the phelloderm and pericyclic only the mi... The parenchyma ... starch grains 3μ to 6μ to 1... ellipsoidal and ... The medullary rays ... with resinous contents, often described as rotenone three to seven cells w... cells.

Constituents. ... chief constituent is rotenone about 2 to 10 per cent.; this ... crystalline substance, formerly named tubatoxin. Three ...

other crystalline constituents are deguelin, tephrosin and toxicarol. It yields to ether about 7 to 25 per cent. of extractive. Benzene gives a stable solution of the active constituents.

These two species of *Derris* can be distinguished by their appearance when viewed in filtered *ultra-violet light*. The fresh[illegible] ransverse surface of *D. elliptica* appear[illegible] a 1 in 20 ether extract [illegible] ether, is allowed to ev[illegible] paper, which is then viewed in U.V.L., the [illegible] appears white. When *D. malaccensis* is similarly examined the freshly cut transverse surface of the root appears orange-yellow and the ether extract residue on filter paper is also [illegible]

Normal caustic soda solution [illegible] roots. When [illegible] 1 in 20 et[illegible] but no precipitate [illegible] similarly treated, a [illegible]

[illegible] is used as a horti- [illegible] by contact aphides, caterpillars, dog fleas, c[illegible] and house-flies; it does not kill cockroaches and bugs. It is not poisonous to man and domestic animals, but the powder produces unpleasant symptoms when inhaled.

The powder is also widely used for the destruction of Warble fly.

Substitutes. The stems, roots and rhizomes of *Derris uliginosa* Benth., a plant growing in the E. Indies and Fiji Islands, occur in commerce. The pieces of stem are usually about 10 to 25 cm. long and 8 to 25 mm. in diameter; two pieces are sometimes intertwined in a manner [illegible] of lianas. Externally the pieces are dull [illegible] longitudinal ridges [illegible] as rusty-red [illegible] than the oth[illegible]

Lonchocarp[illegible] *carpus nicou* D.C., family Leguminosæ, known as C[illegible] Root, *Timbo, Barbasco, Nekko, Haiari* and *Stinkwood*; it is exported from Brazil, Peru, British and Dutch Guiana. The roots grow to a length of 3 or more metres and are usually cut into pieces 4 to 30 cm. long and 1·5 to 2·5 cm. in diameter; externally they are brownish-grey with longitudinal reticulated wrinkles. It contains about 2 to 8 per cent. of rotenone. The microscopical structure of *Lonchocarpus* resembles that of *Derris*, but may be distinguished by the abundant starch grains, individual grains being 6 to 15 to 20 to 35 microns in diameter, the vessels also are larger, being about 300μ to 500μ wide for the larger ones and 30μ to 100μ wide for the smaller ones; the groups of xylem fibres number about twenty-five to thirty-five in each group; the prisms of calcium oxalate are about 20μ [illegible]. As in *Derris*, the fibres of both xy[illegible] for the middle lamella, those of th[illegible], a few rectangular sclereids are p[illegible] and the pericyclic parenchyma. The freshly cu[illegible] transverse surface of lonchocarpus appears greyish-green in U.V.L. and a 1 in 20 ether extract fluoresces bright blue.

SENEGA ROOT. Radix Senegæ, Seneca Snake Root

Sources, etc. Senega root is the dried root and rootstock of *Polygala senega* Linn., family Polygalaceæ, a small plant widely distributed over the United States and the southern parts of British America, the root being collected largely in Minnesota and Manitoba (western senega) and in the north-western of the United States (northern senega). The

root was used by the Seneca Indians as a remedy for snakebite, and was introduced into medicine about the middle of the eighteenth century.

Description. Senega root consists of a slender, greyish- or brownish-yellow root surmounted by a knotty crown, about 1 to 2 cm. in width and 1 to 1·5 cm. high; to the crown are attached the bases of numerous slender aerial stems and numerous buds or small shoots bearing purplish, scaly leaves, which are ovate, 2 to 3 mm. long and have a

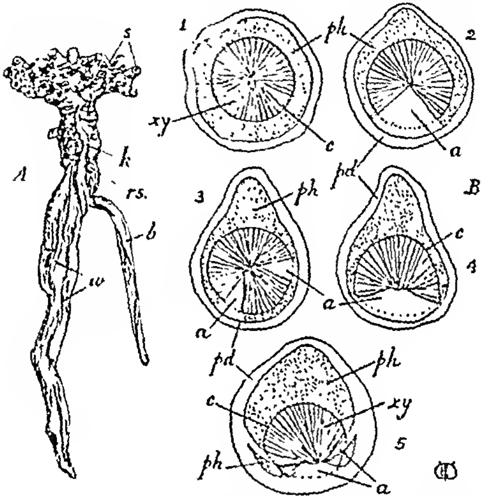


FIG. 165. Root of *Polygala senega*. *A*, habit sketch, natural size. *B*, transverse sections of a root at different places, showing: 1, normal structure, 2, 3, 4 and 5, with one to three abnormal medullary rays. *a*, abnormally wide medullary ray; *b*, side branch; *c*, cambium; *k*, keel; *pd*, periderm, *ph*, phloem; *r.s.*, root scar; *s*, stem base; *w*, wrinkles; *xy*, xylem.

ciliate margin. The stem bases are terete, about 2 mm. in diameter and hollow. The root is usually about 3 to 6 mm. thick at its upper extremity, and tapers slowly, being curved and contorted. It is sometimes simple, but often divides just below the crown into two or three spreading branches, one of which is often at right angles to the main root. *It is longitudinally and sometimes, especially near the crown, transversely wrinkled. Very frequently, but not always, it exhibits a keel resembling a contracted sinew and following a steeply*

spiral course; this keel is prominent on the concave surface of the curves of the tap-root and often extends a considerable distance.

The root breaks with a short fracture, which is smooth in the bark and splintery in the wood. The smoothed transversely cut surface shows occasionally a completely circular mass of wood; usually, however, one, or more rarely two, of the medullary rays is very greatly

secondary phloem which is abnormally developed at one place and, when the root is dried, this ridge of phloem gives rise to the keel. Phloem is replaced by parenchyma in the position adjacent to the very wide medullary rays of the wood. Surrounding the phloem is a narrow band of phelloderm beyond which is a thin cork.

If, after soaking a root in water, the bark is stripped from the yellowish-white wood, the latter shows a longitudinal V-shaped fissure on the convex surface of each of its bends, and the tapering ends of two successive fissures frequently overlap. The fissures are filled with the parenchyma of the unusually large medullary rays, thus giving rise to the wedges or sectors of parenchyma seen in the transversely cut surface, these sectors varying in size and number according to the position where the medullary rays are cut.

Histology. The phellogen produces about four or five rows of thin-walled yellowish-brown cork cells externally and a phelloderm of two to six layers of collenchymatous parenchyma internally. The primary xylem at the centre of the root is diarch and is surrounded by a wide secondary xylem composed chiefly of tracheids and vessels, both of which bear bordered pits. The vessels are narrow, attaining a diameter of about 65μ;

walls. Crystals, starch, fibres and sclerenchyma are all absent from the

numerous branches and buds attached to the crown. In the pericycle of the slender stems there is a band of unlignified pericyclic fibres. The small scale leaves of the young aerial stems have epidermal cells with sinuous anticlinal walls and the stomata are ranunculaceous; the trichomes of the ciliate margin are unicellular, up to 115μ long, with striated walls and blunt tips which are filled with a highly refractive deposit.

The drug has a distinct odour, recalling wintergreen; the taste is at first somewhat sweet, but soon becomes sour and acrid. The powdered root is very irritating to the throat and nostrils when inhaled, and imparts to water the property of frothing.

Northern senega, collected in the north-western States is considerably larger than the usual variety (western senega) ... [illegible] in colour; it is less contorted and shows [illegible]
acrid taste. It is said to be [illegible]

Constituents. Senega root contains as principal constituents senegin, about 4 per cent., and polygalic acid, about 5·5 per cent. These substances are both glycosides, and belong to the group of saponins. Polygalic acid is sternutatory, and senegin is decidedly toxic. Boiling with dilute sulphuric acid converts senegin into sugar and senegenin (Wedekind and Frecke, 1924).

The drug contains a small percentage of methyl salicylate, probably produced by the gradual decomposition of an unknown glycoside. Senega root also contains about 5 per cent. of fixed oil, but is free from starch; it yields about 4 per cent. of ash.

Use. Senega is used as a stimulant expectorant in bronchitis.

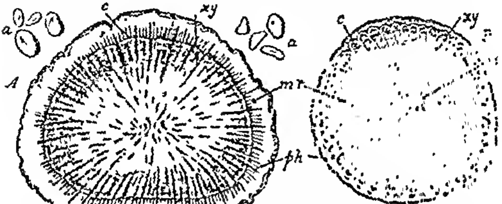


FIG. 100. Calumba root. *A*, transverse surface of a slice of calumba root, natural size. *a*, starch grains × 100. (Both after Berg.) *B*, transverse surface of a sli[illegible] of Coscinium stem, natural size. c, cambium; *m.r.*, medullary ray[illegible] (*B* from *Pharm. Journ.*)

Adulterant[illegible] *ala alba* Nuttall, is collected to some exter[illegible] he root is more slender than western senega, [illegible] spreading branching, and is lighter in colour [illegible] normal wood. The taste is much less acrid than [illegible] ga, and it is presumably less active.

[illegible] ally find their way into parcels of senega, frequently [illegible] areless collection, but the characters given sufficiently [illegible] he genuine drug. Most of the adulterants contain starch or lcium oxalate or both.

·UMBA ROOT. Colombo Root, Radix Calumbæ

abrces. Calumba root is obtained from *Jateorhiza palmata* Lamarck, Menispermaceæ, a lofty climbing plant with annual herbaceous [illegible] nd swollen fleshy roots. It is indigenous to Portuguese East [illegible] owing in abundance in the forest in the region [illegible] much used by the natives as [illegible] es, and also on [illegible] [illegible] use. [illegible] into transverse slices, [illegible] longitudinal slices, and dried in [illegible] imported is known as "natural" calumba;

ciliate ma
and hollow
extremity,
sometimes
three s
main r
crown,
exhibits

it is dingy brown in colour owing to the presence of powdery soil on its surface. It is cleaned by washing and brushing, and is then graded for sale, being now termed "washed" calumba root.

Description. Calumba root occurs in commerce mostly in irregular elliptical or nearly circular slices about 3 to 8 cm. in diameter and 6 to 12 mm. in thickness; they are usually depressed in the centre on both sides; a small proportion consisting of slices cut longitudinally are sub-rectangular and are about 7 to 10 cm. long and 2·5 to 5 cm wide. The outer surface is longitudinally grooved and is covered by a thin, wrinkled, dark brownish-grey layer of cork. The smoothed transverse surface has a greenish-yellow ground in which are embedded greenish-yellow groups of xylem vessels arranged in interrupted radial lines; the xylem is surrounded by a dark cambium line dividing it from the yellowish bark, about 3 to 5 mm. wide, in which the phloem sieve-tissue is evident as darker grey radiating lines, each continuing one of the lines of xylem vessels and tapering towards the cork on the outside. Below the cork, small yellowish points are just visible and are due to the presence of sclereids in the phelloderm. When the transverse surface is treated with sulphuric acid, 66 per cent. by volume, the yellowish vessels and sclereids change to a deep green [illegible]

Histology. The [illegible] radial rows of two [illegible] they are about 65μ to 150μ i[illegible] elongated pits or are reticulate. Surroun[illegible] vessels is a little lignified parenchyma, the cells having simple rounded pits, and a few fibrous tracheids which are often irregularly curved, about 270μ to 400μ long and 12μ to 43μ wide, and have pitted walls. The sieve tissue of the phloem is collapsed to form patches of ceratenchyma. The parenchymatous medullary rays are from six to fifteen or more cells wide, and together with other parenchyma are filled with starch grains which are rounded, ellipsoidal or irregularly ovoid, usually simple, sometimes two to three compound, individual grains being 6 to 25 to 40 to 90μ in diameter, the hilum is eccentric and may be a point or two to four radiate. The sclereids of the phelloderm are [illegible]; about 40μ to 110μ long and 20μ to 60μ wi[illegible] simple pits and having [illegible] than the outer walls. [illegible] prisms of calcium oxalate me[illegible]

Constituents. Calumba root contains two yellow crystalline alkaloids, jateorhizine and palmatine, and two colourless, crystalline, non-alkaloidal bitter principles, columbin and chasmantherin. Columbin appears to be a lactone, and yields, when treated with acid or alkali, yellow amorphous columbic acid, previously believed to be a constituent of the root. Traces of a fluorescent substance, also obtainable from columbin, are present in the drug.

There are also present mucilage and about 35 per [illegible] of starch, but no tannin. The drug yields from 4 to 7 per cent [illegible]

Uses. Calumba is employed as a stomachic and [illegible]

Substitutes and Adulterants. *Columba Rhi*[illegible] present in small quantity and occasio[illegible] the pieces are narrower (often about [illegible]

more woody, and more conspicuously radiate; they also yield more ash (12 to 17 per cent.).

Coscinium fenestratum Colebrooke, family Menispermaceæ. The stems are occasionally imported from Ceylon under the name of Ceylon calumba; these may be cut into slices about the size of calumba, but are readily distinguished by their dark yellow colour, flat surface, not depressed in the centre, and hard, woody (not starchy) nature. They contain berberine (3·5 per cent.). See Fig. 166.

Frasera carolinensis Walter, family Gentianaceæ. *Slices of the root* of this plant have been found substituted for calumba, but the occurrence *is rare; the slices are smaller, thicker, and free from starch, but contain* tannin. This has been termed American calumba.

BRYONY ROOT. Radix Bryoniæ

Sources. Bryony root is the fresh or dried root of *Bryonia dioica* Jacquin, *family Cucurbitaceæ, a climbing and trailing plant, with rough,* hairy leaves, common in hedges and thickets in southern England.

Collection and Preparation. The plant produces in the spring aerial stems attaining a great length, and arising from a large, tuberous rhizome which is continuous with a thick, fleshy root. This subterranean part of the plant is often of considerable size and weight, measuring occasionally at the upper extremity 15 cm. or more in diameter, and reaching a length of half a metre, the whole weighing several kilograms. It tapers more or less gradually towards the tip, and is usually simple. It is dug up in the autumn and is used either in the fresh state or is cut into transverse slices and dried.

Description. When fresh it is of a greyish-yellow colour externally, and marked at close intervals with prominent, transverse, corky ridges often extending half round the root. *Internally the root* is whitish and fleshy, exuding, when cut, a juice that is turbid from the presence of numerous *starch grains. The transverse section exhibits a fine line separating* a narrow bark from a large, fleshy wood; the latter contains, more or less *uniformly distributed over it,* small groups *of vessels, radially arranged* and extending from the centre to the bark. The fresh root has an unpleasant odour and a nauseously bitter and acrid taste.

The dried slices average about 5 cm. in diameter and have a thin yellowish-grey cork, a whitish wood marked with concentric rings and radially arranged vessels; they somewhat resemble calumba, but may be distinguished by their yellowish-grey cork and whitish wood which shows both concentric and radiating ridges.

Constituents. An intensely bitter amorphous alkaloid and a dark-brown resin, both of which are purgative; an alcohol, bryonol, and various fatty acids. The autumnal root contains, further, large quantities of starch.

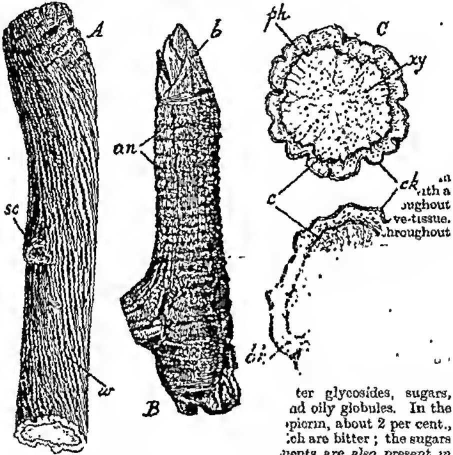
Uses. The root when taken internally in full doses acts as a cathartic and diuretic; applied to the skin it is irritant, and may cause vesication. stems been recommended for pleurisy, whooping cough, and bronchitis, Africa, been given in cases of dropsy.

The root *Bryonia alba* Linn., a continental species, is distinguished by other dise.ious flowers and black berries, the common bryony having contains. wers and scarlet berries. It produces a similar root containing same constituents.

century, and y is the fresh root of *Tamus communis* Linn., family The roots are common climbing plant of the hedgerows and thickets of and to a less ext h root is used as an application for bruises; it is rather the shade. The dr root and is free from bitterness.

GENTIAN ROOT. Radix Gentianæ

Sources. Gentian root is the dried root and rhizome of the yellow gentian, *Gentiana lūtea* Linn., family Gentianaceæ, an herbaceous perennial with large opposite, broadly ovate leaves and yellow flowers. It is indigenous to central Europe, growing abundantly on the lower slopes of the Jura and Vosges mountains, in the Black Forest, and in the Pyrenees. Large quantities are imported from Spain.



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...ter glycosides, sugars,
...ad oily globules. In the
...picrin, about 2 per cent.,
...ch are bitter; the sugars
...uents are also present in
Enzymes which ...

FIG. 167. *Gentiana lutea.* *A*, piece of root. *C*, root cut transversely × 3 *D*, rhiz... annulations; *b*, bud; *bk*, bark; *c*, ... *ph*, phloem; *sc*, scar of a side root; *xy* ... modified.)

... contains gentiamarin
...nzyme action upon gentiopicrin
gentiogenin and dextrose, while
by the action of gentiobiase,
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...ride, gentiobiose and 1 molecule of
...tion of gentiobiase yields ...

Collection and Preparation. The plan... which large fleshy roots are given off ... horizontal course a short distance ... attain a considerable length. Both ... autumn and dried; they are occas... ally. When fresh they are whiti... during the slow drying to which ... yellowish-brown, a ... particular colour a ...

more woody, and more conspicuously radiate; they also yield more ash (12 to 17 per cent.).

Coscinium fenestratum Colebrooke, family Menispermaceæ. The stems are occasionally imported from Ceylon under the name of Ceylon calumba; these may be cut into slices about the size of calumba, but are readily distinguished by their dark yellow colour, flat surface, not depressed in the centre, and hard, woody (not starchy) nature. They contain berberine (3·5 per cent.). See Fig. 166.

Frasera carolmiensis Walter, family Gentianaceæ. Slices of the root of this plant have been found substituted for calumba, but the occurrence is rare; the slices are smaller, thicker, and free from starch, but contain tannin. This has been termed American calumba.

BRYONY ROOT. Radix Bryoniæ

Sources. Bryony root is the fresh or dried root of *Bryonia dioica* Jacquin, family Cucurbitaceæ, a climbing and trailing plant, with rough, hairy leaves, common in hedges and thickets in southern England.

Collection and Preparation. The plant produces in the spring aerial stems attaining a great length, and arising from a large, tuberous rhizome which is continuous with a thick, fleshy root. This subterranean part of the plant is often of considerable size and weight, measuring occasionally at the upper extremity 15 cm. or more in diameter, and reaching a length of half a metre, the whole weighing several kilograms. It tapers more or less gradually towards the tip, and is usually simple. It is dug up in the autumn and is used either in the fresh state or is cut into transverse slices and dried.

Description. When fresh it is of a greyish-yellow colour externally, and marked at close intervals with prominent, transverse, corky ridges often extending half round the root. Internally the root is whitish and fleshy, exuding, when cut, a juice that is turbid from the presence of numerous starch grains. The transverse section exhibits a fine line separating a narrow bark from a large, fleshy wood; the latter contains, more or less uniformly distributed over it, small groups of vessels, radially arranged and extending from the centre to the bark. The fresh root has an unpleasant odour and a nauseously bitter and acrid taste.

The dried slices average about 5 cm. in diameter and have a thin yellowish-grey cork, a whitish wood marked with concentric rings and radially arranged vessels; they somewhat resemble calumba, but may be distinguished by their yellowish-grey cork and whitish wood which shows both concentric and radiating ridges.

Constituents. An intensely bitter amorphous alkaloid and a dark-brown resin, both of which are purgative; an alcohol, bryonol, and various fatty acids. The autumnal root contains, further, large quantities of starch.

Uses. The root when taken internally in full doses acts as a cathartic and diuretic; applied to the skin it is irritant, and may cause vesication.
Stems been recommended for pleurisy, whooping cough, and bronchitis,
Africa, been given in cases of dropsy.
The root *Bryonia alba* Linn., a continental species, is distinguished by
other dise ious flowers and black berries, the common bryony having
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same constituents.
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the shade. The dr root and is free from bitterness.

GENTIAN ROOT. Radix Gentianæ

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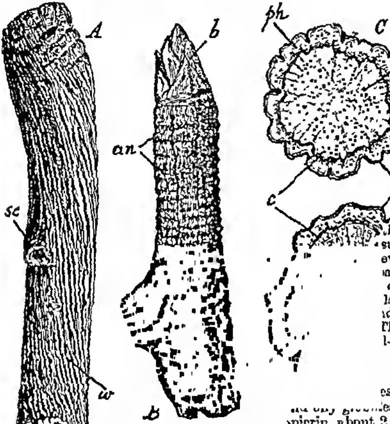


...al ...th a ...ughout ...vo-tissue. ...hroughout ...surrounded ...everal rows ...arenchyma ...of calcium ...lso contain ...ded starch ...The walls of ...l-developed ... See Figs.

...es, sugars, ...ies. In the ...picrin, about 2 per cent., ...ich are bitter; the sugars ...uents are also present in ...enzymes, which are present, ...picrin both in the powdered ...ncture is made *Fermented*

Fig. 167. *Gentiana lutea.* A, piece of root. ... C, root cut transversely × 3. D, rhizom... annulations; b, bud; bk, bark; c, ca... ph, phloem; sc, scar of a side root ... modified.)

Collection and Preparation. ... which large fleshy roots are ... horizontal course a short distance ...ecule of dextrose, and by the action attain a considerable length. B... charide, gentiobiose and 1 molecule of autumn and dried; they are ... action of gentiobiase yields 2 molecules ally. When fresh they are ... verted by invertase into dextrose and during the slow drying to which ... fermentation of the root causes the yellowish-brown, and a distinct ... particular colour and odour re... ol and carbon dioxide, thus lowering the

water-extractive, which may fall as low as 13 per cent. Good gentian yields to water 40 per cent. of extractivo and the amount should not fall below 33 per cent.

The colouring matter of gentian is a yellow, crystalline phenol, gentisin or gentisic acid. The oily constituent is probably a chole- [illegible] to 4 per cent. of ash.

U[illegible] tonic.

Varieties, Substitutes, etc. The roots of other species of gentian are often collected; *Gentiana purpurea* Linn. (Switzerland, etc.), *G. pannonica* Scopoli (Austria), *G. punctata* Linn. (Austria), all yield gentian roots. They are, however, all smaller than those of *G. lutea.* The roots of *G. purpurea*, which approach nearest to the official gentian, attain about half the size and are crowned with several (eight to ten) aerial stems clothed below with many scaly remains of leaves. The top of the root has thus a peculiar branched appearance never found in the root of *G. lutea* (Pharmacographia). All these species appear to possess similar properties.

The rhizomes of *Rumex alpinus* Linn., family Polygonaceæ, have also been found; they are reddish-brown, astringent and bitter, and give a deep red colour with caustic alkalies. *Laserpitium latifolium* Linn., family Umbelliferæ, yields the white gentian of Continental commerce. White gentian of English commerce is said to be derived [illegible]

[illegible] occasionally collected in error for gentian and are a dangerous adulterant. See description, p. 313.

Indian Gentian, Picrorhiza consists of the dried rhizome and roots of *Picrorhiza kurroa* Royle, family Scrophulariaceæ, a plant which grows in [illegible]

greyish-brown and longitudinally wrinkled; it is marked on the underside by scattered circular scars of roots, some pieces having a few roots attached. Closely set scale-leaves are present on the younger part of the rhizome and on the older part are scars of scale-leaves encircling the upper half of the circumference; at a few places the outer part has exfoliated, exposing the black cortex. Some loose roots are present and are dark grey, longitudinally wrinkled, about 1 mm. in diameter and straight or slightly curved. [illegible] urface shows [illegible] mm. wide, a [illegible], and a black [illegible] and the taste very bitter.

Constituents. The drug contains a bitter, crystalline glycoside picrorhizin, about 3 to 4 per cent. and a laxative body named cathartic acid, about 9 per cent.

Uses. Picrorhiza is a bitter tonic and laxative.

MARSHMALLOW ROOT. Radix Althææ

Marshmallow root is obtained from *Althæa officinalis* Linn., family Malvaceæ, cultivated in northern France, Belgium and Bavaria; the plant also grows wild in marshy and moist places near the sea in southern England.

Cultivation and Collection. Crowns of the roots, which were dug up in the autumn, are divided in the following spring into pieces, each having a bud, and are planted in the field. In the autumn of the same year they are dug up, the fleshy roots are removed and the crown... clamp until the next spring. The roots ... scraped to remove the cork and ... longitudinally. They are then drie... ...ated drying-sheds.

Description. The drug consists of straight and slightly tapering roots, about 15 to 20 cm. long and 2 cm. wide at the upper end. The outer surface is yellowish-white and softly fibrous, owing to the exposure of the phloem fibres as a result of scraping awa... there are a few brownish circular ... The roots are obscurely quadr... ...o broad and deep longitudinal fu...

The bark, which can readily be removed in long strips, is tough and fibrous, but the wood breaks with a short granular fracture; internally the root is whitish and starchy. It can easily be cut, and the transversely cut surface exhibits a phloem of moderate thickness, separated by a yellow, slightly sinuate cambium line from the xylem. Both phloem and xylem possess a radiate structure that is more distinct when the surface of the section is moistened; numerous cells containing a translucent mucilage then also become visible. The drug has a faint but characteristic odour, and a mawkish, mucilaginous taste.

Histology. *At the centre of the root is a usually five-arch primary xylem*; this is surrounded by a wide parenchymatous secondary xylem, in which reticulate and pitted vessels occur singly or in groups of two to eight and are surrounded by smaller tracheids, while a few thick-walled xylem fibres are present, singly or in groups of about three to twenty, and are unlignified excepting for the middle lamella. The secondary phloem consists of alternating rings of tangential groups of unlignified phloem fibres and of groups of sieve-tissue, all embedded in a thin-walled, cellulosic parenchyma. Both secondary xylem and phloem are traversed by numerous parenchymatous medullary rays, which are mostly uniseriate, sometimes biseriate. With the exception of scattered idioblasts, the cells of the parenchyma contain starch grains, which are mostly simple, a few being two to four-compound, individual grains measuring 10 to 15 to 20μ in diameter. In the parenchyma are scattered rounded cells containing mucilage, which stains pink with ruthenium red and also cells, each of which contains a cluster crystal of calcium oxalate measuring about 15μ. Sphere crystals of asparagin are present in some cells and give a yellow colour with caustic alkali. Unscraped roots have externally several layers of thin-walled, polygonal tabular cells.

Constituents. The principal constituent is mucilage, about 25 to 35 per cent., which yields by hydrolysis glucose and xylose, but not galactose. The drug contains also about 37 per cent. of starch together with sucrose, asparagin and a substance allied to lecithin. Asparagin, $C_4H_8N_2O_3$, is the amide of aspartic (amidosuccinic) acid, and is found in many plants. Ash about 5 per cent.; it should not exceed 7 per cent.

Uses. Marshmallow root is used as an emollient and demulcent. The powdered root is a useful pill excipient and is also used alone or in association with powdered slippery elm bark for making poultices.

Marshmallow root is sometimes limed, an adulteration which is revealed by a high ash content.

Adulterant. Farwell (1922) ... d for marshmallow a root which was ... vessels were less numerous but la...

BELLADONNA ROOT. Radix Belladonnæ

Sources. Belladonna root consists of the root and rootstock of
is cultivated in
nd, notably in
Much drug is
collected in Roumania and Bulgaria and is shipped from Germany.

Collection and Preparation. The roots are collected from plants which have been grown to yield belladonna herb and they are removed from the ground by ploughing up the field at the end of the season, *i.e.*, in the

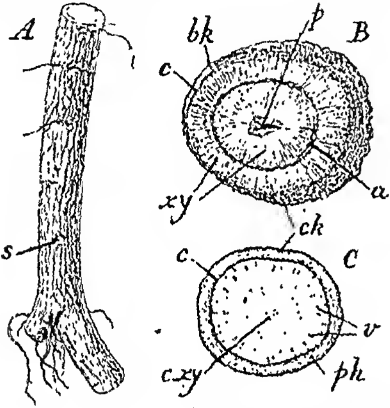


Fig. ... section of a young root, natural size. *C*, transverse section of root × 3. ... mbium; *ck*, cork; *c.xy.*, central ... *s*, scar of lateral rootlet; *xy*, xylem. (From *Pharm. Journ.*, modified.)

autumn, when the plants are three or four years old. The aerial stem bases

they are hard enough to *snap across cleanly* when bent. See also p. 281.

Description. The drug consists of nearly cylindrical roots up to 50 cm. long and 1 to 4 cm. wide, often attached in groups of three or four to a rootstock or crown which is knotty and bears the bases of hollow aerial stems; the root and rootstock, or rhizome, merge into each other imperceptibly. The *roots* are pale greyish-brown and are usually cut into lengths of 10 to 20 cm., the larger ones being split longitudinally. Externally the root is finely wrinkled longitudinally

and bears occasional scars of small lateral roots. The transversely cut surface shows a dark cambium line separating the bark, which occupies about one-fifth of the radius, from the starchy xylem; at the centre is a small mass of xylem vessels including the primary bundles and scattered throughout the remainder of the parenchymatous xylem are small groups of greyish vessels, which in older roots are somewhat radially arranged near the cambium. The fracture is short and mealy or, in roots collected in the spring, it is dark, less starchy and somewhat spongy. The transversely cut surface of the *rootstock* resembles that of the older roots, but has a pith at the centre and the xylem is radiate, woody and usually shows two or three growth rings. The root has an odour recalling liquorice root and a slightly bitter taste.

Histology. At the centre of the *root* is a diarch (rarely triarch) primary xylem and two medullary rays passing outwards, one opposite each protoxylem; the secondary xylem consists of a parenchyma in which the vessels, 40μ to 180μ wide, *occur in small scattered groups accompanied by a few* tracheids and fibres and, in the outer part of older roots, radially arranged; *the xylem is traversed by numerous parenchymatous medullary rays* and small groups of interxylary phloem occur scattered sparsely in the xylem parenchyma. The phloem tissue external to the cambium is parenchymatous with groups of sieve-tissue, but phloem fibres are absent. The outermost tissue of the root is composed of several layers of thin-walled cork cells, beneath which are a few layers of phelloderm. Idioblasts, containing sandy calcium oxalate in the form of monoclinic microsphenoidal crystals, measuring about 1μ to 7μ, occur in all the parenchymatous tissues, most of the cells of which contain small starch grains which are simple or two- to four-compound, individual granules being 15μ to 30μ in diameter.

Constituents. Belladonna root contains the alkaloids hyoscyamine and traces of scopolamine (hyoscine). Other constituents are starch, tannin, volatile bases similar to those of the leaf, and β-methylæsculetin (chrysatropic acid, scopoletin), a crystalline fluoresent principle, widely distributed throughout the family Solanaceæ, and found also in gelsemium rhizome and a number of other drugs.

The total amount of alkaloid that the root contains varies as a rule between 0·4 and 0·8 per cent., but may occasionally rise to 1·0 per cent. Schmidt's experiments indicate that the roots of young plants contain more alkaloid than those of older plants, a conclusion confirmed by Blackie (1926); it is, however, more economical to collect the roots in the third or fourth year. The root yields from 5 to 9 per cent. of ash and from 0·6 to 1·5 of acid insoluble ash.

Uses. Belladonna acts as a local anæsthetic and anodyne, and is often applied as such externally. Internally it is given to check the sweating in phthisis, as a sedative to the respiratory nerves, to relieve spasmodic cough, and in numerous other cases.

Substitutes and Adulterants. *Scopolia Rhizome.* The rhizome of *Scopolia carniolica* Jacquin, family Solanaceæ, is not infrequently found in the belladonna root imported from Germany. The plant grows in the Carpathian Mountains, Czechoslovakia and Roumania. It produces a horizontal rhizome from which aerial stems from 30 to 60 cm. high arise bearing leaves which resemble belladonna leaves but are thinner, more lanceolate in shape, and taper more towards the base (compare p. 285).

The rhizome, which is collected in large quantities and forms one of the sources of the alkaloids hyoscyamine, atropine, and scopolamine, may attain 10 cm. or more in length and about 2 cm. in thickness. It is nearly black in colour and tortuous, and bears on the upper surface numerous large circular depressed stem-scars. It contains hyoscyamine and scopolamine, the total alkaloid (0·6 to 0·7 per cent.) somewhat exceeding in amount that present in belladonna root.

Japanese Belladonna Root, Scopolia japonica Maximowicz, closely resembles scopolia rhizome; it usually contains 0·2 to 0·3 per cent. of alkaloid.

Indian Belladonna Root. Considerable quantities of belladonna root have been imported from India, the bulk having been collected in Kashmir from wild plants of *Atropa acuminata* Royle (= *Atropa lutescens* Jacquemont), which is closely allied to *A. Belladonna.* Indian belladonna root closely resembles the European, but may be distinguished by the section, which exhibits a yellow radiate and zoned xylem. The zonation is due to the alternation of finely radiate cylinders of secondary xylem with very narrow cylinders of parenchyma, through which run small, scattered strands of sieve-tissue. The drug contains 0·3 to 0·8 per cent. of alkaloid.

Phytolacca Root. The root of *Phytolacca decandra* Linn., family Phytolaccaceæ, a plant indigenous to North America but naturalised in southern Europe, has been used to adulterate belladonna. It may, however, readily be detected by the transverse section, which exhibits several concentric rings of wood bundles, in consequence of which large roots easily fissure longitudinally. It breaks with difficulty, splitting longitudinally into fibrous strips. In the parenchyma are numerous idioblasts each containing a bundle of acicular crystals of calcium oxalate. As it attains a much larger size than belladonna root, it is often cut into pieces for admixture. It contains a resinoid substance, phytolaccin, and has a purgative action.

ACONITE ROOT. Radix Aconiti

Sources. Aconite root is the tuberous root of *Aconitum Napellus* Linn., family Ranunculaceæ, collected in the autumn and dried. The drug is obtained in Britain from cultivated plants; in central and northern Europe it is collected from wild plants growing on the lower mountain slopes and is exported chiefly from Germany. Common English names for the plant are monkshood and wolfsbane.

Cultivation and Collection. In cultivating aconite, young tubercles are planted in the autumn, well spaced in rows; early in the following spring the terminal bud on the crown of each root forms a flowering stem and, in the axils of scale-leaves at its base, from one to several buds develop at the ground level into short lateral shoots, each of which forms at its extremity a root crowned by a bud. These roots gradually enlarge and become filled with reserves forming plump conical roots each with a bud at the apex and known as "daughter" roots. The "parent" root gradually shrivels as its reserves are used for the production of the aerial plant, which flowers in July. Each plant usually produces several "daughter" roots which may be as many as six. When the field is dug, sufficient of the "daughter" roots are reserved for replanting and the remainder are well washed and brushed in water and are sometimes deprived of the wiry side roots; they are finally dried in warm air in drying-sheds. The plots are dug every other year and by using two plots alternately a regular yearly yield is ensured. The English drug is produced in this way and therefore consists of "daughter" roots. This method of

cultivation yields a drug which is known to have been obtained from the correct species of *Aconitum*. If seed is used to raise the plants, uncertainty as to botanical source results, because other varieties of *Aconitum* are grown as garden plants and hybrids are easily formed.

On the continent of Europe, aconite roots are usually collected from wild plants. To aid in correct identification, the roots are usually taken from flowering plants and hence they are "parent" roots crowned by a piece of the aerial stem. After washing and trimming the roots are dried either in the sun or better in heated sheds.

Roots are sometimes sliced longitudinally to facilitate drying.

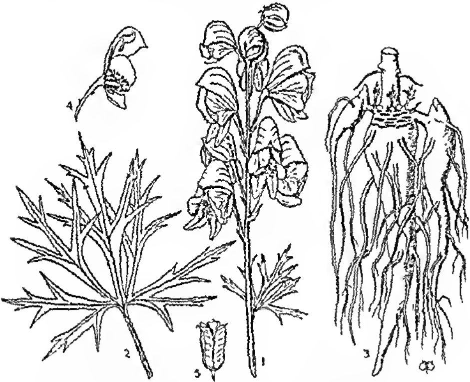


FIG. 170. *Aconitum napellus* L. 1. Racemose inflorescence. 2. Foliage leaf. 3. Root system showing parent root and two daughter roots. 4 Vertical section of a flower. 5. Fruit

Description. The dried roots are about 4 to 10 cm. long, conical in shape, 2 to 3 cm. wide at the crown and tapering to a point at the lower end. Externally they are dark brown, being covered by a suberised metaderm, and bear numerous small circular scars where the fibrous lateral roots have been removed; in some samples, especially of the English drug, these rootlets are present and they contain as large a proportion of alkaloid as the main tap-root. At the widest part of the crown there is one or more scars left by the removal of "daughter" roots from the "parent" roots. *English* aconite is crowned by a large bud with scale leaves and the roots are fairly plump and longitudinally wrinkled. *Continental or German* aconite roots are crowned by a short piece of aerial stem, which is hollow, and they are rather more shrunken

and wrinkled than the English drug. Amongst the continental roots some will be found which show the daughter root, sometimes quite small and sometimes approximately equal in size, attached to the parent root.

The fracture is short, the exposed surface being either white or brown. The smoothed transversely cut surface, at about one-third of the length from the crown, shows a nearly circular outline and a large central pith, which is stellate with about five to eight projecting points. The pith is outlined by a zigzag cambium line and the xylem and phloem elements are inconspicuous. At the apex of each projecting angle is a small mass of xylem and other still smaller groups of xylem at intervals along the inner side of the cambium line. Extending from the cambium to the endodermis, which is very close to and parallel with the margin, is a wide parenchymatous phloem. The narrow strip external to the endodermis is cortex, the outermost layers of which are converted into metaderm by the suberisation of their walls, see Figs 170 and 133.

The odour is slight and the taste is sweetish, then bitter and, after an interval, a sensation of numbness develops and persists for some time.

Histology. The brown outer tissue of the root consists of cells of the cortex, the walls of which have become suberised and so form a protective tissue termed metaderm; this consists of brown tabular cells having no regular arrangement. Within this is a narrow cortex, up to twenty cells wide, bounded on the inside by an endodermis with suberised radial walls; in the cortical tissue are some cells which are thick-walled, pitted and lignified forming characteristic sclereids; occasional similar sclereids are often present in the pericycle.

Just within the pericycle and directly opposite each re-entrant angle of the cambium there is a primary phloem group consisting of sieve tissue; the secondary phloem consists chiefly of parenchyma throughout which there are small scattered groups of sieve-tissue, which are smaller and more numerous near the cambium. The area bounded by each projecting angle of the cambium is occupied by xylem, of which the primary bundle is found in the central position of the xylem elements next the pith, the remaining xylem has been formed by the cambium and consists of small groups of pitted and reticulate vessels embedded in parenchyma. Along the remainder of the cambium line small groups of xylem vessels, usually showing a radial arrangement, occur at intervals projecting into the pith, which is large and entirely parenchymatous. The cells of all the parenchyma of the root contain starch grains which are single or two- to five-compound, individual grains measuring 8 to 12 to 15 to 30μ. Fibres, calcium oxalate and true cork are absent.

Constituents. Aconite root contains three closely allied alkaloids, aconitine, picraconitine and aconine; other constituents are starch and aconitic acid. The total amount of alkaloid present is from 0·2 to 0·6 per cent., and as much as 1·5 per cent. has been recorded. The drug yields from 2 to 6 per cent. of ash.

Aconitine is acetyl-benzoylaconine and is crystalline and easily soluble in ether; picraconitine is benzoylaconine, both picraconitine and aconine are amorphous and insoluble in ether and they are both much less toxic than aconitine.

Uses. Preparations of aconite and its principal alkaloid, aconitine,

when applied to the skin, produce tingling followed by numbness; they are used in certain forms of neuralgia and rheumatism. Administered internally, aconite produces a steady fall of temperature, moistening of the skin, increase in the amount of urine, and lowering of the sensibility; it is given in cases of fever and pain, usually in the form of small doses of the tincture frequently repeated.

Substitutes and Adulterants. *Japanese Aconite Root* (*A. uncinatum* Linn., var. *japonicum* Regel) is regularly imported in considerable quantities. It tapers gradually, and is either dark grey and nearly smooth (daughter root) or brownish, and marked with not very prominent, paler, longitudinal ridges (parent root). It is smaller, more starchy, and less wrinkled than the English root, and exhibits, in transverse section, a circular cambium. It contains japaconitine, which closely resembles, but is not identical with, aconitine, being acetylbenzoyl-japaconine.

Another variety of Japanese aconite root is said to be derived from *A. Fischeri* Reichenbach, and to contain the alkaloid jesaconitine (acetylanisoyl-aconine).

Indian Aconite Root (*A. deinorhizum* Stapf) is much larger than the English, measuring frequently 16 cm. in length and 4 cm. in thickness near the crown; it is yellowish-brown, crowned with the remains of a bud and coarsely wrinkled; internally it may be either starchy or yellowish and horny; the horny character is due to the starch having been completely gelatinised by prolonged heating. The drug contains pseudaconitine (acetylveratroyl-pseudaconine), which is about twice as toxic as aconitine.

The root of *A. chasmanthum* Stapf, contains indaconitine, which resembles aconitine in action; the root is smaller than that of *A. Napellus* (2 cm. × 0·75 cm.), nearly black externally, less wrinkled, fracture lighter, less tough, scars of rootlets clustered at basal extremity; the starch is often gelatinised.

Russian or Soviet Aconite has been ascribed to *A. tianshanicum*, sometimes regarded as a geographical race of *A. napellus* (Fedchenko and Utkin, 1936), a plant growing in Khirghistan. Each piece of this drug consists of about two to four broadly conical tubercles, about 3 to 4 cm. long, joined by their upper parts to form a kind of rhizome. It yields about 1·5 per cent. of total alkaloid, apparently resembling that of *A. napellus*.

Atis Root (*A. heterophyllum* Wallich), small, ovoid, greyish roots with a bitter but not numbing taste; contain the alkaloid atisine, which is much less toxic than aconitine.

SARSAPARILLA. Radix Sarsæ, Radix Sarsaparillæ

Sources. Several varieties of sarsaparilla are imported, but the one known as Jamaica sarsaparilla is the most esteemed in this country. This variety is obtained from *Smilax ornata* Hooker filius, family Liliaceæ, a climbing plant with woody stems, ascending lofty trees, and springing from a stout, knotty rhizome. From the rhizome slender cylindrical roots are thrown off horizontally and creep for many feet a few inches below the surface of the earth. In collecting the roots they are first laid bare and then cut off near the rhizome. After they have been dried they are made into bundles; a number of these are placed upright and bound with wire into a disc-shaped bale.

The plant is a native of Central America (Costa Rica). The root was formerly exported *via* Jamaica; hence the designation "*Jamaica*" sarsaparilla.

Description. Jamaica sarsaparilla is imported in bundles about half a metre long and 12 cm. in diameter, weighing about a kilogram. Each

bundle consists of numerous long, slender roots about 3 mm. in thickness, doubled up and bound loosely with one of the same roots. These usually have a dark reddish-brown colour, are much shrunken and furrowed longitudinally, and bear *tolerably numerous branching rootlets*. They are tough and flexible, not breaking easily even when bent double. The transverse section exhibits a narrow, dark reddish-brown cortex surrounding a central stele, which consists of a ring of yellowish wood with large, radially arranged vessels and a white, starchy pith. The bundles are always free from the rhizome ("chump").

The drug has no odour, and only a slightly bitter taste.

...saparilla. (*From Pharm. Journ.*)

Constituents. The chief constituent in Jamaica, Honduras and probably other sarsaparillas is sarsasaponin, $C_{44}H_{76}O_{20},7H_2O$, a crystalline glycoside yielding by hydrolysis sarsasapogenin and dextrose. According to Power and Salway this is the only definite saponin-glycoside in Jamaica sarsaparilla, which also contains sarsapic acid (a crystalline dicarboxylic acid), dextrose, fatty acids, sitosterol-*d*-glycoside, resin, etc. It has been assumed that sarsaparilla is practically devoid of therapeutic value, but, in all probability this is not the case. Like other drugs containing saponins it possesses hæmolytic properties. The hæmolytic index is the number of cubic centimetres of a suspension of red blood corpuscles just hæmolysed by 1 gramme of the drug. Experiments in this direction have shown that Vera Cruz sarsaparilla has the highest hæmolytic index, Jamaica rather lower and Honduras much lower (Hering, 1930).

Uses. Sarsaparilla has been administered as an alterative in syphilis, chronic skin diseases, and rheumatism, but great diversity of opinion exists as to its therapeutic value.

Fig. 172. Bundle of Honduras sarsaparilla. Reduced. (Pereira.)

Varieties. Several other varieties of sarsaparilla are imported into the English market; the following are the most important:—

1. *Honduras Sarsaparilla*, the botanical origin of which is unknown. The drug is imported from British Honduras in serons containing a number of bundles about 75 cm. long and 5 or 6 cm. wide, much longer and narrower therefore than the bundles of the Jamaica variety; they are sometimes closely whipped round, or sometimes loosely bound with a long root. The roots are distinguished from those of the Jamaica variety by

their pale yellowish or brownish colour, and by their less shrunken, more plump and starchy appearance, they have generally fewer rootlets attached, and are always free from rhizome. The section exhibits a pale, starchy cortex, usually thicker than that of Jamaica sarsaparilla, but a similar stele.

This variety is largely used on the Continent, where it is generally preferred.

2. *Lima Sarsaparilla* is imported from Panama in bundles about 60 cm. long and about 7 cm. in diameter, loosely folded, bound with a root, and made into bales similar to those of Jamaica sarsaparilla. This drug shows a close resemblance to Jamaica ...

cases constitute a most valuable means of identifying and distinguishing these drugs.

3. *Guayaquil Sarsaparilla* is imported in rectangular pressed bales containing a number of flattish bundles about 50 cm. long and 15 cm. wide; the knotty rhizome and portions of the stout, round aerial stems are often present. Sometimes the root is imported loose in bales. It has a mahogany brown colour, is usually larger than the Jamaica, not so much furrowed and with less numerous rootlets.

4. *Vera Cruz* or *Mexican Sarsaparilla* is obtained from *S. medica* Schlechtendal et Chamisso. Both rhizome and roots are collected and

FIG. 173. Bundle of Vera Cruz sarsaparilla. (Pereira.)

dried ... deprived of t... variety is ... ms and exodermis.

5. *Native Jamaica Sarsaparilla* is obtained from plants, presumably of *S. officinalis* Humboldt, Bonpland et Kunth, cultivated on the island of Jamaica. This truly Jamaican sarsaparilla, commercially known as "native" Jamaic... Jamaica (or, bette... bales, and is of a ... scattered, rather ... cortex separated by a distinct line from a rather darker stele. These characters sufficiently distinguish "native" Jamaica sarsaparilla from the Costa Rica drug.

Substitutes. A considerable variety of roots have from time to time found their way into the European markets under the name of sarsaparilla; e.g., roots of *Philodendron sp.*, rhizomes of *Pteris sp.*, etc.; most of them are readily distinguishable from the genuine drug.

JALAP. Radix Jalapæ

Sources. Jalap is obtained from *Ipomœa purga* Hayne, family Convolvulaceæ, a plant with climbing, twining stems indigenous to the eastern slopes of the Mexican Andes. The Spaniards became acquainted with this and similar purgative Convolvulaceous plants

early in the sixteenth century, and exported considerable quantities of them to Europe.

Collection and Preparation. The plant sends out slender runners which are provided at intervals with cataphyllary leaves in the axils of which are buds; below the buds roots are produced, some of which thicken rapidly and form fusiform or napiform members, often of considerable size. These tuberous roots (tubercles) are collected and dried in nets over fires, the smaller entire, but the larger longitudinally incised to allow of the free escape of moisture. When fresh they are fleshy and white internally, but by drying, especially in the manner indicated, they darken in colour. Jalap is imported in sacks from the east coast of Mexico, and distinguished as "Mexican" or "Vera Cruz" jalap.

The jalap plant has been cultivated in India and Jamaica, but these colonies do not at present compete with Mexico in the supply of the drug.

Description. *Jalap tubercles are fusiform, sub-spherical, pear-shaped or irregularly oblong,* about 5 to 10 cm. long and 2 to 10 cm. broad. The small are usually entire, but the larger bear gashes that have been made to facilitate the drying; some specimens are divided into quarters and occasionally the tubercles are cut into transverse slices. Towards the lower extremity they taper off and show a fractured end where the slender part of the root has been broken off. The surface is dark brown, furrowed and wrinkled (but not conspicuously convoluted), and marked with numerous, paler, elongated transverse lenticels. They are heavy and compact, and so hard as to be broken with difficulty but softening readily in water. Internally they have a yellowish-grey or dingy grey colour, and are very tough or horny, the *transversely cut surface exhibiting dark curved lines irregularly arranged.* These lines are due to the formation of accessory or tertiary cambiums, an abnormal development that is met with in some families, notably in the Chenopodiaceæ, Amarantaceæ and Convolvulaceæ. Numerous dark resin cells are visible in all the phloem tissues; the xylem vessels are scattered singly or in small groups throughout the tissue within the outermost cambium ring.

Jalap has a distinct and characteristic odour which is often ascribed to the smoke from the fire over which the roots have been dried, but which is, partly at least, inherent in the drug. The taste is at first sweetish, but afterwards disagreeably acrid.

The heat to which the drug is subjected during the drying is generally sufficiently high to gelatinise some of the starch, especially in the interior of the roots, where the moisture is retained longer than in the outer portions; hence the horny and not starchy appearance of the drug. Roots obtained from cultivated plants in India and Jamaica are usually more carefully dried, and present a mealy, not horny, appearance in the interior.

Histology. The outer surface is covered by a layer of cork composed of brown-walled polygonal tabular cells; beneath this is a band of secondary phloem, about 1·5 to 2 mm. broad at the widest part of the tubercle, formed by the normal circular cambium on its inner margin. Within this cambium is an extensive parenchymatous secondary xylem having vessels scattered singly or in small groups; around many of these vessels or groups, accessory or tertiary cambia arise, some of them circular and others

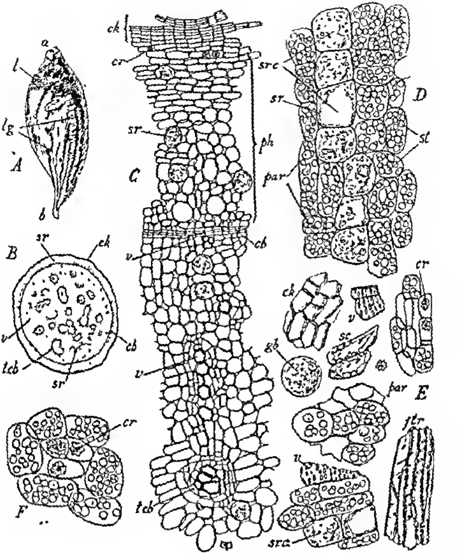


FIG. 174. Jalap, *Ipomœa purga*. *A*, a small tubercle, natural size. *B*, transversely cut surface of a small tubercle × 2. *C*, transverse section of tubercle × 100. *D*, longitudinal section of the same, showing latex cells × 200. *E*, powder of jalap × 200. *F*, part of a longitudinal section, showing calcium oxalate clusters × 200. *a*, point of attachment to plant; *b*, scar left by slender part of the root, *cb*, cambium; *ck*, cork; *cr*, cluster crystal of calcium oxalate, *ftr*., fibrous tracheids; *gb*, globule of secretion, *l*, lenticel; *lg*, longitudinal grooves, *par*, parenchyma; *ph*, phloem; *sc*, secretion cell; *sr*, secretion; *sr.c*., secretion cell; *st*, starch; *t.cb*., tertiary cambium; *v*, vessel.

either as curved lines or long ellipses. The accessory cambia form tertiary xylem on their concave faces and tertiary phloem on the convex faces, so that the whole central tissue comes to enclose numerous small and narrow strands of tertiary phloem. In all the phloem tissue latex cells occur, usually in longitudinal rows and give rise to the dark resinous points seen in the drug scattered throughout the transversely cut surface. The walls

of the secretion cells are suberised and their diameter is about 60μ. The resinous masses stain brown with iodine and red with tincture of alkanna; they are soluble in caustic alkali. The cells of the parenchyma contain starch grains which are simple and rounded or two to four-compound, individual grains being about 8 to 30 to 65μ, with an eccentric hilum, usually having the form of a two- or four-rayed split. Cluster crystals of calcium oxalate, about 15μ to 30μ in diameter, occur in small numbers in some of the cells of the parenchyma, often two to four crystals in a cell; there are also some small prisms, about 6μ long, scattered in the parenchyma. Occasional sub-rectangular sclerenchymatous cells, with a fairly wide lumen, occur in the phelloderm. Fibres are absent from jalap.

FIG. 175. Jalap root. Small specimen, natural size, showing the transverse lenticels.

FIG. 176. Tampico Jalap root. Natural size, showing convoluted surface.

(Both after Greenish.)

Constituents. The principal constituent of jalap is the resin, which can be separated by extracting the root with alcohol, concentrating the tincture, pouring it into water, washing and drying the resinous precipitate. The drug contains in addition colouring matter, mannitol, sugar, starch, β-methylæsculetin, ipurganol, a phytosterin and calcium oxalate.

The resinous precipitate obtained as described is known as "jalap resin." The yield has varied from 2 to 22 per cent. of the drug; 8 to 12 per cent. is often found; under exceptional conditions the quantity has risen in roots cultivated in India to 20 per cent. It is characterised by its partial solubility (about 10 per cent.) in ether, the portion soluble in ether being assumed to be identical with scammony resin. The portion of resin insoluble in ether is often known as jalapin; it is also sometimes named convolvulin.

Jalap resin is glycosidal and yields on hydrolysis glucose together with convolvulinolic and ipurolic acids, which are crystalline substances, as well as formic, butyric and valeric acids.

When jalap resin is boiled with solution of potassium hydroxide the potassium salts of formic, methylethylacetic and other water-soluble acids are formed; consequently, when the alkaline solution is acidified with hydrochloric acid no precipitate is produced (though the solution may show an opalescence due to traces of fat).

Uses. Jalap is a powerful stimulant of the intestinal secretion, producing in small doses a laxative effect, and in large doses active purgation. It is much used as a hydragogue cathartic.

Substitutes and Adulterants. *Tampico jalap* is derived from *Ipomœa simulans* Hanbury, a plant resembling *I. purga* and growing on the eastern slopes of the Mexican Andes. The roots are exported from Tampico (a town on the Gulf of Mexico, about 200 miles north of Vera Cruz), whence it derives its name. This root, which frequently appears on the London market, is distinguished by its irregular shape and remarkably convoluted surface, which does not exhibit the small transverse lenticels characteristic of true (Vera Cruz) jalap. It yields about 10 per cent. of resin, which is distinguished from the resin of true jalap by its complete solubility in ether. This resin (tampicin) is probably identical with the ether-soluble resin of jalap and scammony.

Orizaba jalap (light, woody, stalk, or male jalap) is produced by *Ipomœa orizabensis* (Pellet.) Ledanois. (See below.)

ORIZABA JALAP ROOT. Mexican Scammony, Ipomœæ Radix

Sources, etc. Orizaba jalap root is obtained from *Ipomœa orizabensis* (Pellet.) Ledanois, family Convolvulaceæ, a plant growing near Orizaba in the Mexican Andes (about sixty-five miles south-west of Vera Cruz). It produces a large, woody root which is cut into pieces of varying size and shape and dried. The drug, which has long been known as light, woody, stalk, or male jalap, is imported in considerable quantities, under the name of Mexican Scammony.

Description. The tubercles of Mexican Scammony or Ipomœa are large and fusiform, about 15 to 20 cm. long and 4 to 10 cm. thick, and compared with jalap, they are light in density. Entire tubercles, sometimes slashed longitudinally to facilitate drying, are occasionally imported, but usually they are cut into transverse slices about 0·5 to 2 cm. thick or sometimes as much as 4 cm. and more or less wedge shaped. Externally the tubercles are greyish-black and very coarsely wrinkled. The transverse surface of the slices is rough and fibrous from the projection of numerous woody strands arranged in concentric circles, of which five or six are often present; in the tissue—phloem and parenchyma—between the woody rings there are numerous scattered resin-cells. The slices are tough and the fracture is short, irregular and resinous; the odour is slight and the taste faintly acrid

Histology. The numerous rings of vascular bundles arise by the limited activity of successive cambia. At the centre of the root is a small woody axis consisting of the primary xylem surrounded by the secondary xylem formed by the original cambium, which ceases to function after a limited period; a new accessory cambium now arises in the pericycle and forms a ring of tertiary bundles surrounding the first secondary tissues and

separated from one another and from the central group by parenchyma. After a short time this cambium also ceases to function and accessory cambia are formed successively in the pericycle, producing additional rings of bundles as the tubercle increases in size.

Abundant starch grains are present in the parenchyma, most of them being two- to six-compound, individual grains being mostly muller-shaped and up to 35μ in diameter. Numerous cluster crystals of calcium oxalate, 15μ to 45μ in diameter, occur in the parenchyma and also a few prisms. The xylem contains numerous vessels with bordered pits and also thick-walled xylem fibres. The cells of the cork are thin-walled and usually lignified as well as suberised. The resin or latex cells occur abundantly in the parenchyma of the phloem and the resin stains yellow with iodine water.

Constituents. Like jalap, the chief constituent of Orizaba jalap root is the resin it contains; other constituents of less importance are sugar, β-methylæsculetin, dihydroxycinnamic acid, fatty acids, phytosterol, starch and calcium oxalate. The amount of crude resin varies from 6 to 22 per cent., averaging 12 to 18 per cent.

The crude resin is a very complex mixture. It contains about 6 per cent. of fatty substances, 64·8 per cent. of resin soluble in ether. The ether-soluble portion is not identical with the ether-soluble portion of jalap resin. By alkaline hydrolysis it yields ipuranol, methylbutyric acid, tiglic acid and a product which, by acid hydrolysis, yields dextrose, methylpentose, jalapinolic acid and methyl jalapinolate. The chief constituents, therefore, appear to be the glucoside and methylpentoside of jalapinolic acid and methyl jalapinolate. The following table shows the solubility of certain convolvulaceous resins when treated with various solvents in succession:

	Jalap	Scammony *Convolvulus scammonia*	Mexican Scamm.	Bras. Jalap	*Ipomœa purpurea*
Petroleum Spirit	1·9	4·5	0·2	2·1	8·0
Ether	0·7	92·5	64·8	5·4	7·3
Chloroform	24·1	0·4	0·0	73·4	0·8
Ethyl Acetate	22·0	...	24·8	14·2	23·8
Alcohol	38·8	1·8	2·3	4·7	49·0
Acid Value	15	20	20	...	...
Saponification Value	140	235	180	..	...
Optical Rotation	−37°	−19·8°	−23°	...	...

BRAZILIAN JALAP is the root of *Piptostegia Pisonis* Martius, family Convolvulaceæ. It occurs in the form of transverse, circular slices about 3 to 8 cm. in diameter, and 0·5 to 1 cm. thick, pale greyish-brown, with several concentric rings and numerous pale resin cells; it is less fibrous and lighter in colour than Mexican Scammony. The drug contains about 20 per cent. of resin, about 6 per cent. of which is soluble in ether. Scoville (1918) found 26·5 per cent. of resin, of which petroleum spirit dissolved 3·7 per cent., benzene 5·3 per cent., ether 5·9 per cent., chloroform 19 55 per cent., and acetone 99·4 per cent.; acid value, 23·1; saponification value, 141·6.

The root of *Ipomœa purpurea* Linn. (N. America) contains 4·8 per cent. of a purgative resin.

CHAPTER XIV

Unorganised drugs are materials having a structure that is fairly uniform throughout and are not composed of cells built up into definite plant or animal members or organs. They are usually derived from parts of plants or animals by some process of extraction, such as incision, *e.g.*, opium, decoction, *e.g.*, agar, expression, *e.g.*, olive oil, or are natural secretions such as beeswax and myrrh

The commercial articles so obtained are frequently solids, but some, such as oils and balsams are fluids. In *describing* them, the morphological terms of biological science are inapplicable and one therefore uses various physical characters of form, colour, fracture, etc.; solubilities in common solvents, and chemical tests. These characters and tests enable one to identify and distinguish the drugs included in this category.

Unorganised drugs can be *classified* under headings based upon their origin and nature, giving well-characterised groups, such as dried latex, *e.g.*, opium, and dried juice, *e.g.*, aloes; extracts, *e.g.*, catechu; gums, *e.g.*, acacia; resins, *e.g.*, colophony; gum-resins, *e.g.*, myrrh; oleo-resins, *e.g.*, copaiba; waxes, *e.g.*, beeswax; saccharine substances, *e.g.*, honey; oils and fats, *e.g.*, castor oil, lard; volatile oils, *e.g.*, oil of cloves.

DRIED LATEX

Latex is an emulsion or a suspension, the continuous phase of which is an aqueous solution of mineral salts, proteins, sugars, tannins, alkaloids, etc, and the suspended particles are oil-droplets, resin, gum, proteins, starch, caoutchouc, etc. This turbid fluid is often white in colour, as in the opium poppy, *Papaver somniferum*, but may be yellow, as in *Chelidonium majus*, the greater celandine, or red as in the rhizome of *Sanguinaria canadensis*; it occurs in the plants in special structures named laticiferous cells, tubes or vessels, from which it is obtained by incision into the plant.

Laticiferous tissues then are of three types, cells, tubes and vessels. Laticiferous **cells** are of different sizes and shapes; in jalap, *Ipomœa purga*, family Convolvulaceæ, they are present in the phloem and are large cylindrical cells, about as long as wide and arranged end to end in longitudinal rows, but the end walls are always intact. In euonymus bark, *Euonymus atropurpureus*, family Celastraceæ, the cells are numerous in the phloem and have the form of prosenchymatous fibres with cellulosic walls and latex contents. Laticiferous **tubes** are of two types, branched and unbranched. Unbranched tubes are found in the phloem of *Cannabis sativa*, family Cannabinaceæ, where the cells arise in the growing-point and continually elongate as the plant grows in height, but transverse walls are not formed though the nucleus divides repeatedly, thus producing a cœnocytic structure. Branched tubes occur in *Alstonia scholaris*, family Apocynaceæ, and in *Euphorbia pilulifera* and *E. resinifera*, family Euphorbiaceæ. Each tube is developed from a single cell, which grows in length as the plant grows and at the same time continually branches, but transverse walls are not formed. The laticiferous tubes can always be recognised, when isolated or in longitudinal sections, by their even gently curving walls showing no irregularities and no short projections. Laticiferous **vessels** result from the fusion of numerous cells of the phloem

parenchyma. Typical laticiferous vessels are present in dandelion, *Taraxacum officinale*, family Compositæ, in lobelia, *Lobelia inflata*, family Lobeliaceæ, and in the opium poppy *Papaver somniferum*, family Papaveraceæ. Cells of the parenchyma become filled with latex and the walls of contiguous cells break down thus forming irregular branching structures, which are easily distinguished from "tubes" because of irregularities in the walls and the occurrence of short projections at numerous indeterminate places. See Lobelia, Fig. 116, p. 276.

The walls of all these laticiferous structures are very resistant and consequently the structures can be isolated from the surrounding tissues by maceration on a water-bath in 5 per cent. aqueous caustic potash or soda.

OPIUM

Sources, etc. Opium consists of the dried latex from the unripe capsules of the opium poppy, *Papaver somniferum* Linn., family Papaveraceæ. The drug was known in very remote times, as both the Greeks and Romans were well acquainted with it, and with the manner in which it was collected from the unripe capsule of the opium poppy. The physicians of the Arabian school probably introduced the drug into India as well as into Europe. It was originally used as a medicine, the practice of opium-eating having originated probably in Persia.

Opium is collected principally in Macedonia, Yugoslavia, Bulgaria, Turkey, Persia (Iran) and India.

Cultivation. The poppy which is preferred for cultivation is not a pure strain, but is a cross between *Papaver somniferum* var. *album* and a violet-grey form, so that the petals have a pale greyish-lilac colour. The plants are cultivated in small fields in sunny situations in the plains and valleys and the crop is alternated with maize, tobacco and other crops. Successive batches of seed are sown from September to April so as to avoid loss of the entire crop from frosts, drought or other accident. The seed is sown after mixing it with 3 or 4 parts of sand. The plants are thinned to allow a distance of about 25 cm. between them. Each plant branches near the ground and reaches a height of 50 cm. to 1·5 metres according to the season. They flower during the end of May and the beginning of June and between June and July the capsules, which number about five to eight for each plant, arrive at their full size.

Collection and Preparation. While the capsules are still green or are just showing a tint of yellow, incisions are made into the wall, so as not to penetrate into the loculus, which would result in loss of opium and also prevent the seeds from ripening. Precaution must be taken to choose the time for making the incisions so that neither rain, wind nor dew is likely to spoil the exudation. The incision cuts across the laticiferous vessels and, since these vessels ramify and anastomose throughout the phloem tissues of the capsule wall, the latex from a large area of capsule exudes in small drops along the edges of the incisions and partially dries in the air. The incisions are usually made in the afternoon and the exuded latex is scraped off with a knife or a special instrument early on the following morning.

The type of instrument used and the manner of making the incisions differs according to the country of origin. In Jugoslavia, Bulgaria, Macedonia and Persia a single horizontal incision is made equatorially round the capsule, using a small sharply pointed knife, about 2 to 3 cm. long, mounted in a wooden handle about 8 cm. long. In *Jugoslavia* and *Macedonia* the exudate is collected in conical tins lined with poppy leaf

and holding about 750 g. of moist opium The masses turned out from the cans are soft, conical and covered with poppy leaf. In districts near *Strumitza* the latex is put into tins, such as empty glycerin tins, and is carried in a semi-fluid condition to the factory, where it is dried in warm air. The opium thus produced was formerly known as "soft shipping opium"; it is now mixed at the government factory at Beograd (Belgrade) by passing it through a mill and is made into flat oblong cakes, about 1·5 to 2·5 cm. thick, 18 to 20 cm. long and 6 to 7·5 cm. wide. The cakes are sometimes dried as they are or they may be first rolled in coarsely powdered poppy leaves and then slowly dried, for which purpose they are placed on trays of wire netting stretched on wooden frames and exposed to a warm atmosphere for a long period When finished the cakes usually weigh from 160 to 225 g. each; they are packed with fruits of *Rumex* in cases holding about 80 kilos. Most of this opium goes to the U.S.A.

In *Persia* (Iran) the exudation is scraped off with a knife and collected in a small bowl or on a poppy leaf; it is then mixed and made up into rectangular brick-shaped cakes about 10 × 5 × 7 cm. Each brick, which

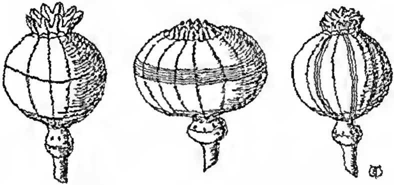


FIG. 177 Capsules of *Papaver somniferum*, showing incisions for the production of opium. From left to right—Macedonian; Turkish; Indian

is wrapped in paper, usually red in colour, weighs about 1 lb and 160 of them are packed in a case for export.

In *Turkey* (Asia Minor) a special cutter is used; this consists of a wooden handle, about 18 cm long, with a flat end in which are embedded seven small knives, the tips of which project about 1·5 mm. so that incisions cannot be made too deeply. The cutter is drawn around the equator of the capsule thus making seven parallel incisions from which the latex exudes. The incision may be repeated after a lapse of two or three days and sometimes the capsules are incised three times The latex is removed with a special copper instrument, shaped like a small tray about 13 cm. long, 5·5 cm. broad and 2 cm. deep, having a wooden handle about 12 cm. long; at a point near the handle there is a gap in the side of the tray, leaving the edge of the base exposed for a length of about 2 cm. This edge is used to scrape off the partially inspissated latex, which is then pushed forward into the front rounded end of the tray. The scrapings are massed into balls of various sizes, wrapped in poppy leaves and packed with *Rumex* fruits for transport to Istanbul, where they are mixed in a mill and moulded into uniform sub-cylindrical cakes about 9 cm high and 14 cm. in diameter, each weighing about 2 kilos; they are packed forty in a case.

In *India* the incisions are made with an instrument named a "nushtur" which consists of three or four small blades, separated by spaces of about

3 mm. and tied together by cotton thread to form a cutter with the cutting teeth projecting about 2 mm. This "nushtur" is drawn from below upwards to make a set of three or four vertical incisions and the operation is repeated on each capsule three or four times at intervals of two or three days. The opium is worked up into a homogeneous mass and is made into cubical cakes for export.

Description. The cakes of opium formed by the collectors in the field have shapes which are rounded, conical, irregular or flattened, and vary much in weight from about 50 g. to several kilograms and they may or may not be covered by poppy leaves. This form of opium is usually referred to as "natural" opium and does not come into regular commerce. The governments of the countries in which opium is prepared have established monopolies in the opium trade and cakes

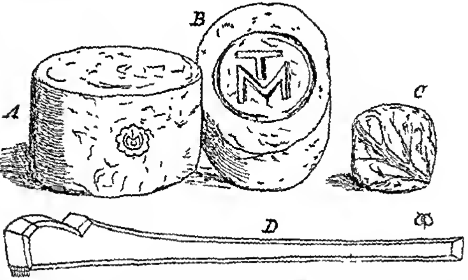


Fig. 178. Turkish opium. *A*, cake of manipulated opium with label (1936). *B*, a similar cake, imported 1944. *C*, cake of natural opium wrapped in poppy leaf *D*, instrument with seven small knives for incising the capsules. *A*, *B* and *C* $\times \frac{1}{4}$; *D* $\times \frac{1}{2}$.

for export are prepared in controlled factories where the "natural" opium is mixed and milled and then made up into cakes of some definite shape containing a fairly uniform content of morphine; this opium is known as "manipulated" opium.

Turkish manipulated opium occurs in sub-cylindrical cakes about 9 cm. high and 14 cm. in diameter, coated with coarsely powdered poppy leaves, giving them a greenish-grey mottled appearance; a circular official label is attached to the side of each cake. The opium has a uniform slightly granular texture and a pale chocolate-brown colour; it is moderately plastic when fresh, but becomes firm and even hard when kept for some time. It contains from 10 to 15 per cent. of morphine. Similar cakes exported in 1944 have a bold device stamped into the upper surface, see Fig. 178B.

Jugo-slavian manipulated opium is in oblong cakes with rounded ends, each weighing 160 to 225 g., the cakes are about 18 to 20 by 6 to 7·5 by 1·5 to 2·4 cm. Externally they are either coated with

broken poppy leaf and are greyish-green in colour or they are devoid of poppy leaf and are dark brown. The interior is uniform in texture and dark brown in colour; this kind of opium contains about 15 to 17 per cent. of morphine and about 10 to 12 per cent. of moisture.

Persian or Iranian opium, produced in the neighbourhood of Ispahan, Shiraz and Meshed, occurs in brick-shaped cakes about 10 by 5 by 7 cm., each wrapped usually in red paper. At times this opium has been moulded into other forms such as conical masses and short sticks. It is brittle and dark reddish-brown in colour and contains about 10 to 12·5 per cent. of morphine. During 1944 brick-shaped cakes have been wrapped in poppy leaves in place of the red paper.

Indian opium, which is produced chiefly in the central districts of the Ganges, including Behar, Benares and Patna, and the tablelands of Malwa to the north-east of Bombay, is controlled by the Government. It occurs in blocks, which are very dark brown or nearly black and internally are smooth and homogeneous. It is imported into Britain in cubical blocks, about 8 to 9 cm. edge, each weighing about 2 lb. and

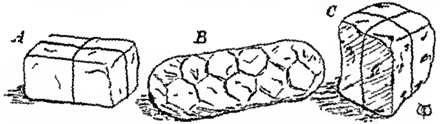


FIG 179. Opium. *A*, Persian opium wrapped in red paper. *B*, Jugoslavian opium showing marks of wire netting. *C*, Indian opium wrapped in white paper. All × ¼.

wrapped in two sheets of thin white paper and tied with string. The blocks are packed in cases containing 160 lb. This opium contains about 13 per cent. of moisture and from 9 to 10·5 per cent. of morphine.

Microscopy. Powdered opium consists of abundant brown granular amorphous masses of dried latex, the masses being irregular in shape;

pieces exhibiting a sectional view show the greater thickness of the outer wall; occasional stomata of the ranunculaceous type are present. Most of these epidermal cells are strongly pitted giving the lumen a stellate form

lower epidermises of tl

composed of thin-walle

the lower epidermis. S

present, the grains being rounded and about 4μ to 8μ in diameter.

Constituents. Opium contains about twenty-five different alkaloids which occur in combination with meconic acid, of which about 5 per cent. is present, and with sulphuric acid. Other constituents are small

quantities of mucilage, sugar, wax, caoutchouc, and salts of calcium and magnesium. It is useful to note that starch (except for very small traces), tannin, oxalic acid and fat are all absent from opium. The most important alkaloids are morphine 10 to 20 per cent., codeine (methyl-morphine) 0·3 to 4·0 per cent., narcotine 2 to 8 per cent., thebaine 0·2 to 0·5 per cent. Narceine, papaverine and the remaining alkaloids are present in very small quantities, constituting together rather more than 1 per cent. of the drug.

Morphine, ($C_{17}H_{19}NO_3, H_2O$ (or $C_{17}H_{17}NO < {OH \atop OH} + H_2O$)), forms colourless crystals, very slightly soluble in cold water but readily in solutions of caustic alkalies or alkaline earths; it is almost insoluble in cold ether (about 1 in 7,000), chloroform, or benzene. Heated with hydrochloric acid in a sealed tube to 140° to 150°, it is partly converted into apomorphine ($C_{17}H_{17}NO_2$). Morphine is a powerful hypnotic, but apomorphine, in addition to a hypnotic action, produces a powerful emetic effect.

Codeine, $C_{18}H_{21}NO_3$, or methyl morphine ($C_{17}H_{17}NO < {OH \atop OCH_3}$) may be obtained from th[illegible] lised, but is usu[illegible] rhombic crystals [illegible] form. It is a strong base, and is liberated from its salts by fixed alkalies but not by ammonia. It has only a mild hypnotic action.

Narcotine, $C_{22}H_{23}NO_7$ or $C_{19}H_{14}(OCH_3)_3NO_4$, crystallises readily in rhombic prisms or needles, and may be extracted from the residue left after treating opium with water; it is a weak base, and has little or no narcotic action, hence it has also been called "anarcotine." It is soluble in 166 parts of ether.

Uses. Opium is one of the most valuable of drugs. It is unexcelled as an hypnotic and sedative, and is frequently administered to relieve pain and to calm excitement. It is also used as an astringent in diarrhœa and dysentery, and as a sedative in certain forms of cough, dyspnœa, etc. Its action is substantially that of morphine. All the important alkaloids have a narcotic action which decreases in the following order: morphine, papaverine, codeine, narcotine, thebaine.

Substitutes and Adulterants. Opium does not appear to be adulterated, though formerly many substances have been reported as adulterants, such as flour, lead shot, powdered poppy capsule, gum, roasted bread crumb, pounded dates, etc. The residue insoluble in water would contain the vegetable débris from many of these and they can be identified microscopically. If powdered poppy capsule has been added, the inner epidermis of the pericarp will be present as well as the outer epidermis, of which a small amount is normally found in opium.

Smoking opium is usually made from Indian opium by digesting the opium in water, boiling and evaporating the extract which is then beaten and carefully roasted; this product is then again extracted with water and the liquor evaporated to a black treacly substance known as "chandoo" or "opium extract for smoking"; it contains about 8 per cent. of morphine. The ash from smoking "chandoo" is known as "opium dross." This "dross" mixed with the ash from "dross opium extract" is boiled out with water to prepare a substance known as "dross opium extract" which is smoked and contains about 7 per cent. of morphine (Browne, 1910).

DRIED JUICES

ALOES. Aloe

Sources. Aloes is the substance obtained by the inspissation of a juice which flows from the transversely cut bases of the large leaves of various species of *Aloe*, family Liliaceæ. Plants of this genus belong

FIG. 180. *Aloe vera* Habit sketch of the plant showing the rosette of large spiny leaves and the inflorescence, × ⅛ (After Engler)

to the Old World and are indigenous to eastern and southern Africa. The species spread to the Mediterranean basin and reached the West Indies in the sixteenth century, and certain species are now cultivated for the commercial production of aloes, especially in some of the West Indian islands off the north coast of South America.

Cultivation and Preparation. The plants yielding aloes bear rosettes of large succulent, subulate leaves, flat or slightly concave on the upper

. . . ver, sessile, with a strong spine at . . . rgins. The leaves are from 25 to . . . base. Some species of *Aloe* bear radical rosettes of leaves and others have stems a metre or more in height, sometimes branched, and bearing a rosette of leaves at the summit of each branch. Plants under cultivation are always dwarf with radical rosettes and they bear spikes of yellow or red flowers.

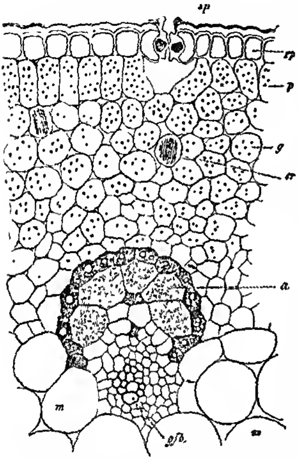


FIG. 181. Transverse section near the margin of an Aloe leaf *ep*, epidermis, *gfb*, vascular bundle, the pericyclic cells, *a*, of which are much enlarged and contain a yellow secretion (aloes); *p*, palisade; *g*, parenchyma; *sp*, stoma, *cr*, calcium oxalate crystals; *m*, mucilaginous parenchyma. *Magnified.* (Tschirch.)

In the islands of Curaçao, Aruba and Bonaire, off the northern coasts of South America, the species *Aloe vera* Linn. (= *A. vulgaris* Lam.) is cultivated. Young offsets are planted in rows about 50 cm. apart, just after the rains break. The first cutting of leaves is made in the second year and a plantation will continue to yield aloes for twelve years, after which the plants are dug up, the ground well worked and manured and replanted.

The vascular bundles in the leaf are isolated and form a line parallel with epidermis at a short distance within the mesophyll. Each bundle has a pericycle formed of very large thin-walled cells filled with a viscous, yellow fluid, known as the aloetic juice. These aloetic cells are somewhat elongated in the direction of the axis of the leaf and they have thin cell-walls. When the leaf-base is cut transversely, the juice flows from those cells actually cut open by the knife and, owing to the pressure of the surrounding tissues, the transverse walls between the aloetic cells in each row break down and the juice is drained from the entire system of pericyclic cells. The aloetic juice is allowed to flow away without assistance by pressure or other means.

In the *West Indies*, especially on the islands of Aruba and Bonaire, the workmen collecting the leaves have their hands and feet well protected against injury by the thorny plants and they put the leaves into kerosene tins in which they are carried to the draining troughs. The cut leaves are arranged along the sides of wooden troughs which are V-shaped and 1 to 1½ metres long, and are tilted so that the juice runs to one end and is received in a tin. The juice is boiled in large copper pans until sufficiently thickened; it is then poured into gourds or boxes and allowed to harden,

thus producing the kind of aloes known commercially as Curaçao or Barbados aloes.

In *South Africa* a basin-shaped depression is made in the ground and is lined with canvas or a goat-skin. The cut leaves of *Aloe ferox* Miller are arranged around this in a circle with their bases directed into the skin; other leaves are placed on top of the first circle and others again on top of these until a mound about 1 metre high is formed, and they are allowed to stand for some hours while the juice drains out into the central chimney and collects in the goat-skin at the base. The skin is emptied into tins from which the juice is transferred to a large iron kettle in which it is boiled down over an open fire, being continually stirred with a large wooden paddle-like instrument. When sufficiently concentrated it is poured into wooden cases, where it sets to a solid mass, forming the type of aloes known commercially as Cape Aloes, and is exported from Mossel Bay to Cape Town in Cape Colony.

On the *Island of Socotra* and the neighbouring mainland of *East Africa* aloes is obtained from *Aloe Perryi* Baker and probably other species. This juice is collected in a goat-skin lining a depression in the ground and is often carried in a skin to the coast in a semi-liquid condition. Other portions of the juice are inspissated by spontaneous evaporation by the sun's heat and thus is transported in a pasty condition. Arab traders take the drug to Bombay and it is re-exported in kegs or tins to Europe.

Zanzibar aloes is often regarded as a variety of Socotrine aloes, but this is very doubtful and its precise origin is unknown. It is poured into skins in which it solidifies and the skins containing the aloes are packed in wooden cases for export. This aloes is often known as "monkey"-skin aloes, but the skins are usually those of some small carnivorous animals, not of monkeys. Some Zanzibar aloes is apparently allowed to evaporate in small depressions lined with leaves, thus forming small cakes about 8 cm. in diameter and coated on one side with a leaf.

Vitreous and Hepatic Aloes. The manner in which the inspissation is performed has a remarkable influence on the physical characters of the aloes. If the juice is rapidly concentrated, the concentration carried as far as practicable, and the resulting aloes quickly cooled, a drug is obtained that breaks with a vitreous or glassy fracture, and in small splinters is quite homogeneous and transparent even when examined under the microscope. Such an aloes is termed a "vitreous," "lucid" or "glassy" aloes. But if the evaporation is carried on slowly and not quite so far as in the preceding case, a drug is obtained that is opaque and exhibits when examined under the microscope minute crystals embedded in a transparent resinous mass. Such an aloes is termed "hepatic" or "livery". The crystals that it contains are aloin, and the reason why in this case the aloin crystallises, while in the vitreous aloes it does not, is probably to be found partly in the fact that the conditions under which evaporation takes place are more favourable to crystallisation, and partly in the conversion of the crystalline aloin to an amorphous modification (see below). Nevertheless every variety of aloes not only may, but actually does, occur in both the vitreous and the opaque modification.

Description. 1. *Socotrine Aloes* arrives usually in kegs or tins, or occasionally in large barrels, and commonly has a pasty, semi-liquid, or even treacly consistence. It is then of a brownish-yellow colour and quite opaque, but if not too viscid it separates on standing into a clear, dark brown, supernatant liquid and a dark yellow sediment which, under the microscope, is seen to consist of minute crystals of aloin.

As this variety of aloes contains a varying amount of water, and is not, as imported, in a suitable condition for use in pharmacy, it must be dried at a gentle heat, best by exposing it on wooden trays in a warm room. It then forms hard, dark brown or sometimes, if dried at too high a temperature, nearly black masses, breaking with a dull, waxy, uneven, often markedly porous fracture, and possessing a strong, characteristic cheesy and unpleasant odour and an extremely bitter, nauseous taste. It should be almost entirely soluble in alcohol, and yield about half its weight to cold water. Small splinters are opaque, but mounted in a drop of almond oil and examined under the microscope they exhibit numerous minute prismatic crystals (of aloin)

FIG 182. Zanzibar aloes in skins, packed in cases. (Greenish)

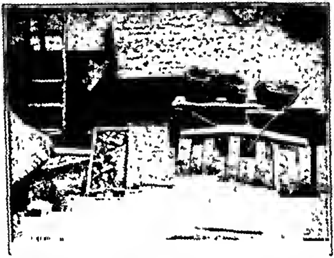
embedded in a transparent, dark yellowish-brown mass. This aloes therefore belongs to the class of aloes known as livery or hepatic aloes

2. *Zanzibar aloes* is usually hard, but is sometimes soft, and then the contents of the case become compacted into a solid mass. Pieces of the so-called "monkey" skins are found with the aloes. Another form of this aloes consists of small flattened oval cakes about 7 by 5 cm. It has a liver-brown colour, and a dull waxy, but nearly smooth and even fracture, usually showing a few very small cavities Its odour is characteristic but not disagreeable, and the taste is very bitter.

Both the foregoing varieties of aloes occur also in the vitreous variety, but are seldom imported in this condition.

3. [illegible] black colou[illegible] glassy fract[illegible]wn or amber-yellow colour, and exhibit no crystals when examined under the microscope. It belongs, therefore, to the class of glassy, lucid, or vitreous aloes, and may be easily distinguished from all other glassy aloes by its very distinctive sour odour and by the pale yellow colour of its powder. Although normally quite vitreous, when kept under suitable conditions crystals may make their appearance.

4. *Barbados Aloes* or *Curaçao Aloes*. No aloes is now produced in the island of Barbados, and that which bears this name is in reality prepared in the Dutch islands of Curaçao, Aruba, and Bonaire; it is therefore more appropriately termed Curaçao aloes.



A B C

FIG. 183. A, Curaçao aloes in gourds B, Curaçao aloes in case C, Socotrine aloes (Greenish)

Curaçao or Barbados aloes arrives usually in boxes, sometimes in gourds It occurs in the vitreous as well as in the livery variety; the former, commercially known as "Capey" Barbados, may become opaque on keeping, a change to be ascribed to the slow crystallisation of the aloin It is also by no means uncommon to find packages that are partly filled with glassy, partly with opaque, aloes; such differences in the appearance are probably due to slight differences in evaporating the juice.

Livery Curaçao aloes of good quality varies in colour from yellowish- or reddish-brown to chocolate-brown, lower grades being black and occasionally burnt. It breaks with a dull, waxy, even fracture, small splinters exhibiting under the microscope numerous minute crystals of aloin.

Vitreous Curaçao aloes, which is not a highly esteemed variety, is distinguished from the livery by its transparency. It has usually,

in small fragments, a garnet-red colour; in other respects it resembles the foregoing.

Curaçao aloes has an intensely bitter taste and a strong penetrating odour which is faintly reminiscent of iodoform.

All varieties of aloes have a *density* of about 1·33

Microscopy. The four kinds of aloes can be distinguished, when in the form of powder, by microscopical examination of the sample mounted in lactophenol. Cape aloes then appears as transparent brown irregular and angular fragments; Curaçao aloes shows fragments composed of innumerable minute slender prisms or needles; Zanzibar aloes shows irregular lumps with embedded nodular masses, individual sphærites being about 10 to 20μ in diameter; Socotrine aloes consists

FIG. 184. Powdered aloes. Fragments of *A*, Cape; *B*, Curaçao; *C*, Zanzibar and *D*, Socotrine aloes. Mounted in lactophenol. All × 150.

of fragments composed of fairly large prisms grouped irregularly into masses; see Fig. 184. The sphærites of Zanzibar aloes show a good cross in polarised light.

Note. For the *microscopical examination of powdered aloes*, it will be found that the use of almond or other oil or of liquid paraffin or glycerin is not so good a mountant as lactophenol. Lactophenol brings about a gradual solution of the particles and the crystals become rapidly and clearly evident as shown in Fig. 184.

Constituents. The principal constituent of all the foregoing varieties of aloes is the pale yellow, crystalline glycoside, barbaloin (formerly called socaloin, zanaloin, capaloin, etc., according to its origin). In Curaçao aloes the barbaloin is accompanied by isobarbaloin, which is crystalline and isomeric with barbaloin, but easily distinguished from barbaloin by chemical tests. Socotrine and Zanzibar aloes contain no isobarbaloin, and Cape aloes traces only.

The crystalline aloin is accompanied by an amorphous aloin, β-barbaloin, which may be produced by heating barbaloin for about three hours to 160° to 165°; it is isomeric with barbaloin, and constitutes part at least of the water-soluble substances other than barbaloin and isobarbaloin. β-barbaloin is particularly abundant in Cape and Uganda aloes.

Other constituents of aloes are resin and aloe-emodin, in addition to water-soluble substances (other than the aloins) of which nothing definite is known. The resin of Curaçao aloes consists of barbalore-sinotannol combined with cinnamic acid; that of C... of Zanzibar and Socotrine aloes ... with paracumaric acid, ... probably mixtures of decomposition ... arising partly during the process of hydrolysis.

Aloe-emodin is a decomposition product of barbaloin and occurs in small proportion only.

Barbaloin, which is closely related to frangulin (see p. 79), is sparingly soluble in water, more ... ol and acetone. It is a glycosidal meth... ling on hydrolysis aloe-emodin- ... 1932). Rosenthaler proposed the ... Leger has suggested the formula ...

The proportion in which the aloins are present in the respective aloes is not accurately known. Tilden (1872) and Tschmann (1880) obtained from 20 to 25 per cent. of aloin from Curaçao aloes. Carr and Reynolds (1907) found in a number of specimens from 12·6 to 27·9 per cent. As no exact assay process is known, and as there appears to be ... in its extraction, it may be assumed that ... upwards of 30 per cent. of crystallise... aloes appear to contain less. Cape ... per cent, Léger estimated the barbaloin in Cape ... about 5 to 6 per cent. and the β-barbaloin at about 14 per cent., and the total aloins in livery Curaçao aloes at about 30 per cent., but these figures do not rest upon any substantial basis. Rowaan (1936) found 8 to 12 per cent. of aloin in Curaçao aloes and states that Cape aloes contains about one-half that amount. Kiefer considers that the chief purgative constituents of Cape aloes are three resins, two of which are soluble in solution of sodium bicarbonate and one in solution of sodium carbonate (in all about 66 per cent.) whereas the aloin (5 per cent.) contributes but little to the purgative action. *It is obvious, therefore, that the chemistry of aloes is very insufficiently known.*

Chemical Reactions There are chemical tests for certain of the constituents of aloes and they are used for the identification of aloes and for the determination of the particular variety.

1. *Borax Test.* Make a 1 per cent. solution of aloes in boiling water, cool and clear with kieselguhr. To 10 ml. of the clear filtrate add 0·25 g. borax and dissolve by heat; pour some of the dark fluid into water and a green fluorescence is produced (Schouteten's reaction) All the four kinds of aloes described respond to this test. The green fluorescence is said to be formed from the aloe-emodinanthranol liberated from barbaloin by hydrolysis with borax (Rosenthaler, 1932).

2. *Bromine Test.* To some clear solution of aloes, prepared as above, add an equal volume of saturated solution of bromine A yellow precipitate of tetrabromaloin is formed All the four kinds of aloes described respond to this test.

3. *Test for Anthraquinone Derivatives.* Carry out the test as directed for rhubarb (see p 320) and a positive reaction is obtained with Socotrine, Curaçao and Cape aloes, *but not with Zanzibar aloes, though a faint reaction is sometimes obtained, especially if a larger amount of the aloes is used.* This test is a modification of Bornträger's reaction which, as originally designed, does not always give a satisfactory result.

4. *Cupraloin test* for isobarbaloin. Use 10 ml. of a 0 1 per cent. solution

of aloes in *distilled* water and add 1 drop of a 5 per cent. solution of copper acetate, 0·5 ml. of saturated sodium chloride solution, and 1 ml. of alcohol and warm. A deep wine-red colour is formed with Curaçao aloes and an evanescent pale wine-red with Cape aloes. (This test is sometimes known as Klunge's reaction.) Socotrine and Zanzibar aloes give no reaction.

5. *Nitric Acid Test.* *To 5 ml. of a 1 per cent. clarified solution* add 2 ml. of nitric acid (s.g. 1·42). With cape aloes a vivid green is produced; with Curaçao aloes a deep brownish-red; with Socotrine aloes a pale brownish-yellow; with Zanzibar aloes a yellowish-brown.

If strong nitric acid is added directly to a little powdered aloes on a tile, Cape aloes acquires a green colour after an interval of about five minutes; Curaçao aloes gives a crimson colour; Socotrine and Zanzibar aloes give a yellowish-brown colour.

Uses. All the varieties of aloes have a more or less powerful purgative action, Cape aloes being the strongest, all of them acting with remarkable slowness. Aloes is one of the most valuable purgatives in certain forms of constipation, as it improves the digestion and does not lose in activity by repetition.

Substitutes and Adulterants. *Natal Aloes.* This variety of aloes, which is seldom, if ever, imported, is believed to be derived from *A. candelabrum* Berger, a native of the country near Pietermaritzburg. None has been imported in recent years.

Natal aloes is almost always opaque, and has a characteristic dull greenish-black or dull brown colour. In odour it closely resembles Cape aloes, and it may therefore be easily distinguished from all other opaque aloes by this character alone. It yields when scraped a pale greyish-green or sometimes pale yellowish powder, and when this is mixed with a little sulphuric acid and the vapour of nitric acid blown over it, a deep blue coloration is produced; this character is very distinctive.

Natal aloes contains nataloin, homonataloin, and a resin consisting of nataloresinotannol combined with paracumaric acid. It does not respond to the borax test for aloes. It is only weakly purgative.

Mocha Aloes is occasionally imported from Bombay in tin-lined cases;

KINO. East Indian, Malabar, Madras, or Cochin Kino

Sources. Malabar kino is the juice obtained from incisions in the trunk of *Pterocarpus Marsupium* Roxburgh, family Leguminosæ, evaporated to dryness. The tree grows in southern India and Ceylon.

Collection and Preparation. The phloem of the tree contains, according to v. Höhnel, numerous comparatively wide and short tubular cells arranged in axial rows; these cells are filled with a red astringent fluid, which flows from them when they are wounded. Vertical incisions, with oblique lateral ones running into them, are accordingly made in the bark; the juice that flows is collected in small cups made of leaves, or in other convenient receptacles, and soon dries in the sun to a dark mass that readily breaks up into small angular grains. It is sometimes boiled before it is evaporated, an operation that modifies the subsequent behaviour of the drug. Kino has been imported as a treacly liquid which can easily be dried.

Description. Kino occurs in small, glistening, angular grains that appear quite black and are remarkably free from dust, the grains are about 3 to 5 mm. in diameter or sometimes as much as 10 mm. When thin laminæ or the edges of the grains are examined they are seen to be transparent and of a dark ruby-red colour. They are hard and brittle, breaking with a vitreous fracture and yielding a brownish-red powder. The drug is odourless, but has, when chewed, an astringent taste, and adheres to the teeth, colouring the saliva red.

In cold water kino is only partially (from 80 to 90 per cent.) soluble; it dissolves to a greater extent in hot water, and is almost entirely soluble in alcohol, 90 per cent. The aqueous solution turns green on the addition of a ferrous salt, violet with an alkali, and throws down a precipitate (kinotannic acid) when acidified with a mineral acid.

Constituents. The principal constituent of kino is kinotannic acid, of which it is regarded as containing from 70 to 80 per cent. The published assays vary within very wide limits (24 to 96 per cent.), but this variation is probably due partly to variation in the drug, partly to variation in the process adopted for the assay, and partly to the gradual production of oxidation products intermediate between the soluble kinotannic acid and the insoluble kino-red. Hooper (1925) found 24·9 per cent. by the cinchonine method and 28·8 per cent. by the hide-powder method. The change from kinotannic acid to kino-red commences immediately the juice is exposed to the air, as evinced by a darkening in colour, and may proceed rapidly in solutions of the drug, which may gelatinise owing to the formation of insoluble kino-red. It is caused by the presence of an oxydase enzyme, and may be prevented by destroying the activity of the enzyme by boiling the juice or the solution of the drug. Hence the boiling of the juice before evaporation is a rational procedure. When fused with caustic potash kinotannic acid yields phloroglucin and protocatechuic acid, it appears, therefore, to be allied to quercitannic acid.

In addition to kinotannic acid and kino-red the drug contains about 10 to 15 per cent. of moisture, and small quantities of pyrocatechin (catechol), gallic acid, and mineral constituents (ash 1·5 per cent.).

Uses. Kino is a powerful astringent; it is given internally for diarrhœa and dysentery and is also used externally.

Substitutes. Kinos have been obtained from numerous plants belonging to various families including Leguminosæ, Myrtaceæ, Polygonaceæ, Myristicaceæ, and Saxifragaceæ Of these kinos the following may be briefly mentioned:—

1 *Botany Bay kino* from various species of *Eucalyptus* (Australia), the most suitable being *E. calophylla* R. Brown, family Myrtaceæ, the tannin of which does not gelatinise. The drug occurs in irregular dark red pieces.

2. *African kino* from *Pterocarpus erinaceus* Poiret, family Leguminosæ, in West Africa It contains about 50 per cent. of kinotannic acid and closely resembles the official drug.

3. *Jamaica kino* is an extract obtained by evaporating a decoction of the leaves, wood and bark of *Coccoloba uvifera* Linn, family Polygonaceæ.

RED GUM. Eucalyptus Kino, Gummi Eucalypti

Sources. Eucalyptus Kino, or as it is commonly termed "red

gum," is a variety of Australian kino obtained from *Eucalyptus rostrata* Schlechtendal, and other species (*E. marginata* Smith, *E. amygdalina* Labillardier, etc.), family Myrtaceæ. They are all Australian trees, *E. rostrata* forming large forests on the banks of the Murray River in New South Wales and yielding a valuable timber.

Collection and Preparation. *E. rostrata* is usually preferred as the source of red gum for medicinal use, because the tree is gregarious, cannot easily be mistaken for others, and yields freely a drug of good quality. The gum, which is secreted in cavities in the wood, or sometimes between the bark and the trunk of the tree, forming carbuncles, is obtained by making an incision and inserting a trough-shaped piece of tin by which the treacly liquid as it drains from the cut is carried into buckets or tins. In a few days it dries into a solid mass which soon becomes friable, breaking up into very dark fragments; or it may be evaporated by boiling, and much of the drug is probably prepared by this method. The yield of each tree is very variable, the average being about a litre, some yielding none, others as much as 18 litres (Maiden, 1897).

Description. Red gum occurs in commerce in small irregular pieces, about 5 to 10 mm. in diameter. They are dark reddish-brown, opaque, hard and brittle, and more or less dusty, but thin laminæ are transparent and ruby-red, the powder being pale reddish in colour. When chewed it is somewhat tough, and has an astringent taste, colouring the saliva red and adhering to the teeth. Cold water dissolves from 80 to 90 per cent. According to Brownscombe (1899) good qualities [illegible]

C[illegible] per cent of kinotannic [illegible]ituent. Hooper (1925) found 16·3 per cent. by the cinchonine method and 20·4 per cent. by the hide-powder method. There is also present kino-red, a gelatinisable tannin glycoside, catechin, pyrocatechin, and about 15 per cent. of moisture, the remainder consisting of substances not at present exactly known. According to Smith (1904), eucalyptus kinos contain two tannins giving with ferric chloride a violet and a green reaction respectively; the former gelatinises readily but the latter does not.

Uses. Red gum is not so powerful an astringent as kino, but its action is said to be slower and more prolonged.

BUTEA GUM. Bengal Kino, Buteæ Gummi

Sources. Butea gum is the juice obtained by incising the stem of *Bu*[illegible] family *Leguminosæ*, and subsequently dried.

D[illegible]lly occurs in small, irregular, angular fra[illegible]dull, *buff-coloured portions of the cortex and cork of the stem* sometimes adhere. When fresh it is ruby-red, transparent in small fragments, and brittle; but on keeping it becomes dull, nearly black, opaque and tough. It is readily reduced to a reddish powder and has an astringent taste. It is partially soluble in water and in alcohol.

Constituents. The chief constituent is kinotannic acid (15 to 62 per cent.); the insoluble matter may vary from 10 to 46 per cent.

Uses. Similar to those of kino.

EXTRACTS

UNDER this heading are grouped together drugs prepared by evaporating aqueous decoctions of parts of certain plants or animals.

GAMBIER. Pale Catechu, Terra Japonica, Catechu

Sources. Gambier is an extract prepared from the leaves and young shoots of *Uncaria gambier* Roxburgh, family Rubi[illegible] plant is a climbing shrub indigenous [illegible] largely cultivated on [illegible] as well as in Briti[illegible] of the Archipelago. The d[illegible] Europe towards the end of the eighteenth ce[illegible], but was probably used in India at much earlier times for chewing with betel leaf (the leaf of *Piper Betle* Linn.).

Description. Gambier usually occurs in the form of tolerably regular cubes, measuring from 2 to 3 cm. each way; it is light in weight, and of a dull, dark reddish-brown colour externally, which, however, varies slightly, even on different sides of the same piece. The [illegible] even, with a few minute cavities, slight[illegible] cubes break easily and [illegible] porous and friabl[illegible] [illegible]itter and astringent b[illegible]

Gambier of goo[illegible] almost entirely soluble in boiling water, and yields not less than 80 per cent. to alcohol The residue insoluble in water consists mainly of pieces of epidermis, trichomes and other vegetable débris of the young leafy twigs used in its preparation. Some samples, however, do not yield any appreciable residue, owing apparently to careful straining of the liquor during preparation.

Cultivation and Preparation. Plantations of *Uncaria gambier* are made in clearings in the damp, virgin jungle at elevations not above 500 ft. above sea level. Seed is sown in a nursery and, when about nine months old, they are planted out about 3 metres apart in the clearing. A first crop is taken when the plants are one and a half to two years old and are about 2 metres high, coppicing being the usual manner of treatment. The yield is at its best about eight years after planting and good crops continue for about twenty years The shoots are cut down with a broad-bladed knife and are carried to the factory in loose rattan baskets or on carrying-poles. The young leafy plants are thrown into a cauldron about three-quarters full of boiling water; the cauldron has an iron bottom and sides of hard wood, it is about 1.5 metres in diameter at the top and is heated by a log fire made beneath it in a hollow in the ground. The contents are boiled for about three hours, being stirred and bruised with a four-pronged wooden fork. The marc is finally removed by wooden forks having three large flat prongs and is thrown on to a sloping trough about 6 metres long and projecting over the edge of the cauldron so that the liquor may drain back into it, the marc is washed with a little water and is pressed in the trough. The decoction is evaporated for about one and a half hours till it turns yellowish green, thick and pasty; it is then transferred to wooden tubs holding 4 to 5 gallons each The tubs are cooled in a stream and the contents are stirred with a pole about 30 cm. long and 4 cm. thick to induce crystallisation. After about ten minutes the semi-crystallised magma is poured into shallow wooden trays to a depth of 2 to 3 cm. and is allowed to set. While still moist it is cut with a wooden knife into cubes,

which are spread on rattan trays to dry in the sun. Much gambier is poured into kerosene tins to solidify and is imported in large blocks. Cube gambier is preferred for pharmaceutical use.

A little of the powdered drug mounted in water and examined under the microscope exhibits numerous minute acicular crystals of catechin. The residue left after extraction with water or with alcohol may also be examined for starch which should be absent. The ash should not exceed 5 per cent.

Constituents. Gambier contains about 7 to 33 per cent. of catechin and 22 to 50 per cent. catechutannic acid, these two substances in varying proportions constituting together over 60 per cent. of the drug. These figures, however, vary with the care with which the drug has been prepared, and also with the method used for determining the tannin. Hooper (1925) found 40 per cent. of tannin by the hide-powder method but only 10 per cent. by the cinchonine, the difference being due to the absorption of catechin by the hide-powder in addition to tannin. Brown substances, rubinic and japonic acids, of unknown chemical nature are also present.

Other constituents of the drug are catechu-red, quercetin, and gambier-fluorescein, a fluorescent substance, the presence of which can be shown by preparing a filtered alcoholic solution of the gambier, making it strongly alkaline [illegible] petroleum which acquires a [illegible] distinguishes gambier from c[illegible]

Uses. Gambier is employed medicinally as a local astringent in the form of a lozenge or as a general astringent in diarrhœa; its use for these purposes is, however, insignificant compared with the quantities consumed in the dyeing and tanning industries and for other technical purposes.

Adulterants. Gambier has been adulterated with mineral matter (clay, ferric hydroxide, etc.), starch and astringent extracts.

CUTCH. Catechu, Black Catechu, Catechu nigrum

Sources. Cutch is an extract prepared from the heartwood of *Acacia catechu* Willdenow, family Leguminosæ, a tree of medium size common in India and Burma. It yields a valued timber, and also an astringent [illegible]

and that obtained from *Acacia catechu* is to be regarded as true catechu. To avoid confusion it would be well to adhere to the terms "gambier" and "cutch" for the two drugs, thus avoiding the use of the term "catechu," which has been applied to both.

Cutch has long been used in India as a masticatory, but it was not introduced into Europe till the latter half of the seventeenth century.

Preparation. To obtain the drug the tree is felled, the bark and sapwood (which are used for tanning) stripped from the trunk, the dark red heartwood cut into chips and boiled in water in earthen pots. The decoction is then strained and boiled down in iron pots with continual stirring until it attains the consistency of syrup. When sufficiently cool to handle, the extract is spread upon leaves (of *Dipterocarpus tuberculatus* Roxburgh, *Cassia Fistula* Linn., etc.), arranged within a wooden frame or

mould and left for the night. In the morning the cutch is dry, and forms brick-like masses weighing about 20 kg., which are broken up for the market.

Description. Cutch occurs in nearly black masses, the outer portions of which are hard and brittle, but the interior often still soft; portions of leaf are often adherent to the outer surface. It breaks easily, the fractured surface having a dull gloss, and containing a number of small cavities. It yields a dull brown powder and has no odour, but an astringent and subsequently sweetish taste.

When macerated with cold water it forms a brown magma, which exhibits under the microscope numerous minute crystals similar to those found in gambier. Boiling water dissolves it almost entirely, but on cooling deposits a crystalline sediment.

Constituents. Cutch closely resembles gambier in chemical composition. It contains as principal constituents catechutannic acid, about 25 to 33 per cent., and acacatechin, about 10 to 12 per cent. Acacatechin differs from the catechin of gambier in its formula, $C_{15}H_{14}O_6,3H_2O$, and melting point. The drug contains in addition catechu-red and small quantities of quercetin, but is free from the fluorescent substance that is present in gambier. Although the two drugs, gambier and cutch, as usually found on the market, have little resemblance to one another, this is due solely to the manner of preparation, the syrupy liquor being in the case of gambier allowed to crystallise. This method is sometimes pursued in India with cutch, and the resulting drug, "katha," then closely resembles gambier, but can always be distinguished from it by the absence of the fluorescent substance.

Uses. Cutch is employed chiefly in the dyeing and tanning industries, especially in the latter; it is much used for tanning fishing nets, etc.

Substitutes. Similar extracts are also prepared from other substances and called "cutch"; thus mangrove cutch is obtained from the bark of *Rhizophora mangle* Linn., and of *Ceriops candolleana* Arnold, family Rhizophoraceæ, which contains 42 per cent. of tannin.

CURARE

Sources. Under the name of curare several (at least three) varieties of a dark, extract-like mass have appeared in commerce. They are all arrow poisons prepared by tribes of Indians in the valleys of the Amazon and Orinoco and their tributaries. The manner in which these extracts are prepared, and the ingredients, vegetable or animal, that enter into them are only imperfectly known. The bark of various species of *Strychnos* (*S. Castelnæi* Weddel, *S. toxifera* Bentham; *S. Gubleri* G. Planchon; *S. Crevauxii* G. Planchon, etc.), family Loganiaceæ, appear to be essential constituents. In the bark of these plants considerable quantities of poisonous alkaloids are present.

Description. Curare has been imported in gourds, in small earthen pots, and in bamboo tubes, but gourd curare is now no longer a commercial article. It has the appearance of a very dark brown or nearly black extract resembling black catechu, often containing small cavities. That imported in bamboo is dark brown and granular, the broken fragments frequently exhibiting crystals of quercite sufficiently large to be visible to the naked eye. It has little or no odour, but a very bitter taste.

All these varieties of curare are poisonous when injected subcutaneously, but when administered by the mouth they are harmless, producing, it is said, the effect of a stomachic tonic. The degree of toxicity varies not only in the different varieties, but in different specimens of the same variety, and the strength, therefore, of each parcel must be determined before it

can be used medicinally. Bamboo curare yields to water about 84 to 88 per cent., gourd curare 34 to 75 per cent., pot curare 50 to 87 per cent. (Bohm, 1898). These figures suffice to show the extreme variability of the drug.

Constituents. Gourd curare contains the alkaloids curarine and two quaternary bases, calabashcurarine I and calabashcurarine II; curarine is amorphous and extremely toxic; no strychnine is present, the South American species of *Strychnos* appearing to be free from this alkaloid. Bamboo curare contains tubocurarine and curine. Pot curare contains protocurarine, protocurine, protocuridine and neoprotocuridine.

Uses. Curare has been employed as a remedy for hydrophobia and chorea; it has also been found useful for tetanus, but it would appear desirable to abandon the use of the crude drug in favour of that of its active alkaloids.

LITMUS, Lacmus.

Litmus is a colouring matter obtained from various lichens of the sub-class Ascolichenes, chiefly *Roccella tinctoria* de Candolle (Cape Verde), *R. Montagnei* Bel. (Madagascar), *Ochrolechia leucophæa* Linn., etc.

Preparation. The method of preparation is guarded as a trade secret, but it appears to depend mainly upon the slow fermentation of the soaked and ground lichen in the presence of ammonium and potassium carbonates. A red colour is first produced which gradually changes to blue. The blue liquid is drawn off and evaporated, with the addition of chalk and gypsum; the mass is then cut into small rectangular cakes and dried. The cakes have an edge of about 6 mm.; they are dark blue to bluish-violet, finely granular and friable. Litmus used as an indicator in acidimetry has a pH range of 5 to 8

Constituents. The chief constituents are erythrolitmin and azolitmin, together with erythrolein and spaniolitmin. The lichens themselves contain lecanoric acid, erythrin and orcin; by the action of alkalies, these yield orsellinic acid; orsellinic acid by further chan[illegible]ls orsin, from which, by oxidation in the presen[illegible]ring matters are produced.

Cud[illegible] an analogous me[illegible] Ach.

AGAR-AGAR, [illegible] Isinglass. Agar

Sources. Agar is the bleached [illegible] concentrating [illegible] to the class [illegible] from species of *Ge*[illegible], *G. amansii* Kutz., *G. polycladum* S[illegible]aceæ; small amounts of other genera may be included such as *Gracilaria lichenoides* Grev.

Preparation. In Japan the seaweeds are collected in May and in October, being removed from the ocean floor by raking with long-handled rakes or by diving from small boats. Poles are sometimes driven into the sea-bed to encourage the growth of the algæ upon them; the poles are removed and the weeds stripped from them. They are then spread upon the beach to dry. The dried seaweeds are beaten and shaken to remove shells, sand, etc., and are taken to factories at high altitudes in the interior. Here the weed is washed in water, bleached by exposure to the sun and then boiled in open boilers for five or six hours with about fifty times its weight of faintly acidulated water (about 1 of sulphuric acid in 40,000).

The liquor is strained through cloth and transferred to wooden troughs about 100 cm. by 40 cm. and 8 cm. deep, where it is allowed to cool in the open air and the liquid congeals. The jelly is cut into pieces about 5 × 8 × 40 cm., using knives guided by a ruler. These rectangular pieces of jelly are put into wooden cases of slightly larger internal dimensions, one end of which is covered by wire netting; the jelly is then forced through the netting by means of a wooden plunger pushed into the case. The narrow strips thus formed are spread out on rush mats to dry and bleach in the frosty air and sunshine. The alternate freezing and thawing of the product helps to remove the water from the strips, and for this reason the manufacture is conducted in the winter only.

Description. Japanese agar occurs in greyish-white, translucent strips about 60 cm. by 0·5 to 1·0 cm. and 0·1 mm. thick, occasionally in flattened sticks, about 30 cm. long by 2·5 cm. wide and 5 to 7 mm. thick and having a slightly yellowish tint. The surface is crinkled and somewhat micaceous and various species of diatoms are found

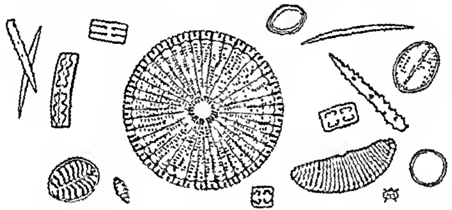


FIG. 186. Diatoms and sponge spicules from a specimen of agar-agar. × 250. The large discoid diatom is *Arachnoidiscus ornatus*. Two sponge spicules are seen lying one over the other on the extreme left of the drawing, and two others, separate, on the right

embedded in it, the most characteristic being species of *Arachnoidiscus*, which is discoid and has a sculpturing on its valves in the form of radiating lines and concentric circles, producing a resemblance to a spider's web. Agar is tough and difficult to break; it has a slight odour of marine algæ and a faintly salty mucilaginous taste. It swells in cold water and 0·75 to 1·0 per cent. boiled with water forms a colloid fluid, which sets to firm jelly on cooling. One drop of N/10 solution of iodine added to 10 mils of the decoction (1 in 100) rapidly cooled produces a pale yellowish colour, 0·5 mil a very dark colour, but if slowly cooled a brownish colour.

Constituents. Agar is composed chiefly of a calcium salt of a sulphuric ester of a carbohydrate complex $R(O.SO_2.O)_2Ca$. When hydrolysed by boiling with dilute hydrochloric acid it yields a limpid liquid containing galactose (β-galacto-pyranose) and sulphuric acid; this reaction immediately distinguishes agar from gelatin and similar substances. Agar contains a small trace of proteins, about 1 to 2 per cent., and this is insufficient to yield any evidence of ammonia when

agar is heated with dry soda-lime, a test which also distinguishes agar from gelatin and albumen. The ash is about 3·5 per cent.

Uses. Agar-agar is largely used for the preparation of bacteriological culture media, the high melting-point (98°) of the jelly rendering it particularly suitable for this purpose; the jelly resolidifies at about 40°. Agar passes through the intestinal canal almost unchanged, but absorbs water during its passage and thus promotes peristalsis, for which purpose it is frequently used.

Note. A material, which when properly adjusted for pH and for gelling point can be used as a bacteriological medium, is now (1945) being prepared in Britain from specis of *Gigartina* and other indigenous rhodophyceæ. This is being marketed (1945) under the name of "British Agar." Agar from New Zealand is made chiefly from *Pterocladia lucida*, that from Australia from *Gracilaria confervoides* and that from U.S.A. from *Gelidium cartilagineum*.

GELATIN. Gelatinum

Sources. Gelatin is a protein derivative, often classed as a scleroprotein or albuminoid, obtained by evaporating an aqueous extract made from skins, tendons, and bones derived from various domestic animals, such as the ox *Bos taurus* Linn., the sheep *Ovis aries* Linn., etc., family Bovidæ, all belonging to the order Ungulata of the class Mammalia.

Preparation. The details of the manufacture of gelatin vary in different factories; the following is a generalised outline of the process. Raw material consisting of skin and tendon is first subjected to a preliminary treatment, known as "liming," the material being steeped for fifteen to twenty or even forty days in a dilute milk of lime. This process dissolves the fleshy matter, removes chondroproteins of the connective tissues and saponifies fat. The hides, etc., are then thoroughly washed in running water.

Bones are usually ground and defatted by treatment with benzene or some other organic solvent in closed iron cylinders; after defatting, the mineral matter is sometimes removed by treatment with hydrochloric acid.

The treated material from the skins, tendons or bones is now heated with water in open pans with perforated false bottoms or sometimes under pressure. The clear fluid is run off and is evaporated under reduced pressure until the gelatin content is about 45 per cent. It is then run into shallow metal trays or trays with glass bottoms and allowed to set to a jelly. The jelly is removed and placed in trays with a wire netting bottom; these trays are passed through a series of drying rooms at temperatures, increasing by about 10° C. each time, from 30° C. to 60° C.; this drying process takes about a month. Sometimes bleaching by sulphur dioxide is used to produce a light-coloured product.

The bones and other materials contain the collagen protein named ossein, which is converted, by the addition of water during the boiling, into gelatin.

Description. Gelatin occurs in thin sheets, or in shreds, or powder which may be nearly colourless or pale yellow and almost free from odour and taste. It is hard and brittle; when broken it at first bends and then breaks suddenly with a short fracture. In cold water it swells and when heated dissolves; it is soluble also in acetic acid and glycerin, but not in alcohol, ether, etc. A 2 per cent. hot aqueous solution should gelatinise on cooling, but this property is destroyed

by the prolonged action of heat. Boiling with diluted hydrochloric acid converts it into the hydrochloride of glutin-peptone.

Constituents. Gelatin consists chiefly of the protein glutin and, when it is heated with soda-lime, ammonia is evolved, showing the presence of nitrogen of which it contains about 18 per cent. Gelatin responds to the usual tests for proteins; its solution in water gives a white precipitate with tannic acid and a yellow precipitate with trinitrophenol (picric acid); with Millon's reagent it gives a white precipitate which becomes brick-red on boiling.

Gelatin should be free from chondrin, which is formed from the chondrinogen of connective tissues; the absence of chondrin is shown by the solubility of gelatin in acetic acid and by its failure to produce a precipitate with lead acetate, alum, ferric chloride and copper sulphate, all of which precipitate chondrin. The absence of sulphur from gelatin is shown by adding lead acetate and then caustic potash and boiling when no blackening results, a test which distinguishes gelatin from albumen.

When treated with potassium dichromate and exposed to the light, gelatin is rendered insoluble. Formic aldehyde (formalin) forms an insoluble condensation product with gelatin.

It yields from 0·6 to 2 per cent. of ash; it contains about 12 to 17 per cent. of moisture.

Uses. Apart from its various technical uses, gelatin has been employed as a nutrient and as a styptic, but its value for these purposes has been over-rated. It is also used as a basis for glycerin suppositories, for the preparation of pastilles and for the preparation of nutrient media for the growth of bacteria, some of which cause liquefaction of the medium.

Note. *Isinglass* (Ichthyocolla) is the dried prepared swimming bladder of the sturgeon, *Acipenser huso* Linn. (Order *Sturiones*), and other species of *Acipenser* living in the Black Sea and Caspian Sea and the rivers which flow into them. The bladders are cut open, washed, soaked in water, spread out on a board and deprived of the outer, silvery membrane. Dried in sheets they form leaf isinglass, or several folded together, book isinglass, or rolled and folded, staple isinglass. It is prepared for use by cutting it into thin shreds This variety is known as *Russian Isinglass*.

Isinglass is whitish or pale yellow, semi-transparent, tasteless, but with a more or less perceptible odour. In cold water it softens and swells; with boiling water it forms a solution which (1 in 50) gelatinises on cooling. It consists chiefly of collagen, about 80 per cent., together with water, about 15 to 20 per cent.

Isinglass can be distinguished from gelatin by soaking it in cold water and examining the softened material microscopically. Fibrous structures are then evident in the isinglass, whereas gelatin, similarly treated, is structureless.

Brazilian isinglass is made from the swimming bladders of species of *Silurus* and *Pimelodus*; it is usually yellowish or brownish in colour and is regarded as an inferior variety, used chiefly for technical purposes.

CHAPTER XV

GUMS AND SACCHARINE SUBSTANCES

Gums are amorphous, translucent solids, insoluble in alcohol and in most organic solvents; they are, however, soluble in water to yield viscous, adhesive solutions, or are swollen by the absorption of water into a jelly-like mass. They consist of calcium, potassium and magnesium salts of aldobionic acids and can be hydrolysed by prolonged boiling with acids when they yield mixtures of sugars and complex organic acids. The sugars so formed are monosaccharides, usually pentoses such as arabinose, xylose and tragacanthose or hexoses such as galactose. The acids liberated by hydrolysis are uronic acids, *i.e.*, acids derived from monosaccharides by the oxidation of the primary alcoholic group which they contain, two of the simplest uronic acids being glucuroni
the uronic acid is combined b
an aldobionic acid, formerly
of acid also found in pectins and hemicelluloses. In the gums these aldobionic acids occur as salts of calcium, potassium and magnesium.

Gums are yielded by trees and shrubs belonging to a number of families, but especially Leguminosæ, Rosaceæ, Rutaceæ, Anacardiaceæ, Combretaceæ, and Sterculiaceæ. They are produced by the conversion of the cell-walls of the tissues into g
means of an enzyme of the origin of

Gums are abnormal products, result
brought about either by injury or
growth and are usually formed by changes in existing cell-walls.

Mucilages are similar in constitution to gums, but are normal products of cell activity, being secreted in the cell and laid down like hemicelluloses, often in such quantity as to completely fill the cells. In the epidermal cells of linseed and of ispaghula as also in the cells of the roc ...ns are present and are used up during ...he mucilage.

The ... produced from starch differs essentially from the gums in being entirely converted into dextrose by dilute mineral acids; it is strongly dextrorotatory, natural gums being slightly lævorotatory.

ACACIA GUM. Gum Arabic, Acaciæ Gummi

Sources. Acacia gum is a dried exudation from the stem and branches of various species of *Acacia*, family Leguminosæ, especially of *A. senegal* Willdenow (= *A. verek* Guill. et Perr), a small tree attaining a height of 5 or 6 metres, and growing freely both in Western Africa (Senegambia) and in Eastern Africa (the upper Nile districts), possibly also in Central Africa, forming forests of considerable extent. Normally gummosis occurs in the ceratenchyma and phloem parenchyma, it may also be induced by wounding the stem when gummosis appears to take place in the cambium or the young phloem tissue?

Bacteria, moulds and other organisms may gain admittance to the gum-forming tissues through the wounds, but whether these take an initial part in the formation of the gum is more than doubtful.

Collection and Preparation. The best gum is produced near Kordofan from trees specially cultivated and worked for gum. The trees are kept properly pruned from dead wood and the lowest branches are removed; shrubby undergrowth is cleared away to allow easy approach to the trees and to freely admit air and light. The formation of gum is greatly increased by wounding the stems and it then apparently takes place first in the young phloem and cambium. Towards the end of November and again in February and March the tapper visits trees about six or seven years old, and drives a long-handled axe with a small blade just under the bark of the stem and large branches without injuring the cambium. By twisting the axe and pulling it back he leaves two ends. One of these he pulls up and the other down, and so removes a strip of bark 0·5 to 1·0 metre long. About three to six weeks afterwards the gum which forms in tears near the lower end of the wound is collected and the orchard is picked over every four to six days until rain sets in, when the exudation of gum ceases. The gum thus collected is brought by the Arabs to one of the gum markets; all of those in the Kordofan province are under government supervision, and the gum is sold under such supervision After sale it is taken to the merchants' sheds, transferred to double sacks, conveyed to El Obeid and railed thence to Port Sudan. Gum is also spontaneously exuded from wild trees, but this is usually rather darker in colour and not so valuable.

The gum, when collected, is in translucent tears which, "ripened" by exposure to the sun, develop cracks and become friable. Native girls clean it by picking out pieces of bark and sifting out the sand. Such ripening or bleaching as is now done is done at El Obeid.

In some districts another *Acacia* yielding smaller quantities of gum (*A. Seyal* Delile) occurs. The gum, which is called talk or talka gum, is collected by the natives with that of *A. senegal* (hachab gum) As talka gum is of inferior quality it has to be separated by picking.

Description. Kordofan (hachab) gum, which is the best variety, occurs in rounded or ovoid tears, about 0·5 to 4 or sometimes as much as 6 cm. in diameter. They are often quite white, but sometimes show a yellowish tinge, and are opaque from the presence in the outer part of the tears of numerous small fissures. In consequence of these and the brittle nature of the gum, they easily break up into a number of small, transparent, angular fragments with glistening, vitreous surfaces. The drug is practically inodorous, and has a bland, mucilaginous taste. While the finest qualities are white, or have at most only a yellowish tinge, inferior grades have a decided yellow or reddish or brownish-red colour and then contain traces of tannin. Gum is also exported without undergoing the process of ripening; such gum is often in large tears and has far fewer cracks in it.

Acacia gum is insoluble in alcohol, but dissolves freely in water, forming a translucent, viscid, but not glairy or ropy liquid, that feebly reddens litmus paper. A 10 per cent. aqueous solution of good qualities is slightly lævorotatory, and when boiled with an equal volume of Fehling's solution throws down a slight but distinct deposit of cuprous oxide. Solution of lead acetate produces no precipitate, but subacetate produces a copious white one, while a saturated solution

of borax forms with a strong solution of gum a clear, translucent jelly. Inferior (brown) gum usually contains tannin which may be detected by solution of ferric chloride.

Powdered gum acacia when mounted in alcohol has the appearance of small angular transparent fragments; on the addition of water, by irrigation, the particles gradually become rounded and diminish in size until they finally disappear. When mounted in solution of ruthenium red the particles of powder remain colourless.

Constituents. Acacia gum consists almost entirely of a glycosidal acid of high molecular weight, which has been termed arabic acid, combined with potassium, magnesium, and calcium; by hydrolysis each molecule yields two molecules of arabinose and four of galactose together with an organic acid termed isogeddic acid, which is isomeric with geddic acid, obtained from geddah gum. The glycosidal acid of acacia is, therefore, diarabinan-tetragalactan-isogeddic acid, the termination "an" indicating the anhydride of the corresponding sugar. This acid can be obtained from the gum by acidifying an aqueous solution with a mineral acid, dialysing it until the mineral constituents are removed, and fractionally precipitating with alcohol. Whilst moist it dissolves in water but the dried acid only swells in water, dissolving on the addition of an alkali.

Gum acacia also contains an oxydase enzyme, and hence readily turns powdered guaiacum resin, or the tincture diluted with water, blue. It loses about 14 per cent. of moisture when dried at 100° and yields from 2·7 to 4·0 per cent. of ash. It contains further a small percentage of nitrogen, but this does not enter into the composition of the gum itself (distinction from gelatin, etc.); it is probably due to the enzyme, from which the gum cannot be entirely freed.

Variety. *Senegal gum* is exported in large quantities from the Senegal river to Bordeaux. It is derived from *A. senegal*, but may be distinguished from Kordofan gum by being (usually) slightly more coloured, less fissured and by containing vermiform tears.

Uses. Acacia gum is used medicinally as a demulcent and as a means of suspending oils, resin, etc., in aqueous fluids.

Substitutes and Adulterants. *Sennaar gum, Gedaref gum, Ghezirehgum, Talka gum, Somali gum, Aden gum*, etc., are varieties of East African gums and are considered inferior to Kordofan gum; the latter gives a lævorotatory solution, whereas many of the other East African gums give a dextrorotatory solution.

Mogadore gum (*A. gummifera* Willdenow); is mostly dark in colour and but little fissured; occasional white fissured tears are probably Sudan gums.

Indian (Acacia) gums include Amrad gum (*A. arabica*), Amritsar gum (*A. modesta*), etc. The flora of the deserts of Sind resembles that of the African deserts. The gums are often in large tears varying in colour from yellow to dark brown, and are used for calico printing, etc. (For ghatti gum see below.)

Cape gum (*A. horrida* Willdenow) and Australian gum (*A. dealbata* Link; *A. pycnantha* Bentham) find application in various industries.

Many of these gums form glairy, ropy solutions with water, and when diluted throw down gelatinous deposits of gum that has swolled but not

dissolved. An acacia gum suitable for pharmaceutical use should be free from both these characters, and should further give no reaction for starch

sugars, etc.).

GHATTI GUM. Gummi Indicum

Sources. Ghatti gum is obtained from *Anogeissus latifolia* Wallich,

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acture is
ecipitate

with solution of lead subacetate (that of acacia gum gives a copious one). With water it forms a nearly colourless mucilage of much greater viscosity than that made with the same proportion of acacia; the mucilage is glairy and ropy.

Constituents. The constituents of ghatti gum are, as far as is known, similar to those of acacia. Ghatti gum also contains an oxydase.

Uses. Ghatti gum is well adapted for pharmaceutical use, it has excellent emulsifying properties.

TRAGACANTH GUM. Tragacantha

Sources. Tragacanth gum is a dried, gummy exudation from the stem of *Astragalus gummifer* Labillardière, family Leguminosæ, and other species of *Astragalus*.

Collection. The plants are small, branching, thorny shrubs, about a metre in height, and are natives of southern and eastern Europe and especially of Asiatic Turkey and Persia, where they form one of the most characteristic forms of vegetation. When the stem is incised a gum exudes and dries, the form that it assumes being dependent on the form of the incision, vertical slits yielding flat, ribbon-shaped pieces and punctures vermiform tears. It is produced by the transformation of the cell-walls of the pith and medullary rays into gum, which easily absorbs

expose the roots, make incisions and return after a week to collect the gum. The first tapping gives a white, the second and following, yellow gum.

In some districts accidental wounds by grazing cattle appear to suffice

Europe. The former variety is known as Smyrna, the latter, which alone is official, as Persian.

Description. *Persian tragacanth* occurs in thin, flattened, curved, ribbon-shaped flakes of a translucent, horny appearance and nearly colourless or faintly yellowish. The flakes are often 3 cm. long, 1 cm. wide, and about 2 mm. thick, and are marked with numerous con-

of borax forms with a strong solution of gum a clear, translucent jelly. Inferior (brown) gum usually contains tannin which may be detected by solution of ferric chloride.

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Constituents. Acacia gum consists almost entirely of a glycosidal acid of high molecular weight, which has been termed arabic acid, combined with potassium, magnesium, and calcium; by hydrolysis each molecule yields two molecules of arabinose and four of galactose together with an organic acid termed isogeddic acid, which is isomeric with geddic acid, obtained from geddah gum. The glycosidal acid of acacia is, therefore, diarabinan-tetragalactan-isogeddic acid, the termination "an" indicating the anhydride of the corresponding sugar. This acid can be obtained from the gum by acidifying an aqueous solution with a mineral acid, dialysing it until the mineral constituents are removed, and fractionally precipitating with alcohol. Whilst moist it dissolves in water but the dried acid only swells in water, dissolving on the addition of an alkali.

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Many of these gums form glairy, ropy solutions with water, and when diluted throw down gelatinous deposits of gum that has swelled but not

bean, a tree which grows freely in Cyprus and Egypt and other Mediterranean countries.

Preparation. The seeds are flattened ovoid, smooth, dark red-brown ... ight known as a "carat," ... 10 mm. long, 6 to 7 mm. ... point in the centre of the narrower end and lies between the micropyle and the strophiole, from ...

... special machinery, each seed ...

... al concavo-convex or plano- ... and 1 mm. thick, ... and very difficult ... d has a somewhat ... ficially resembling powdered gum tragacanth. The powder is insoluble in alcohol, but swells with water to form a viscous mass, which gives no blue coloration with iodine (distinction from tragacanth) and no coloration with solution of ruthenium red (distinction from sterculia gum).

Powdered carob gum mounted in alcohol appears as small angular particles which swell rapidly when water is added. If mounted in iodine water, the granular cell contents stain deep yellow, showing the presence of protein, the cell-walls remain colourless. When mounted in solution of chloral hydrate, the swollen cell-walls are evident.

Constituents. Carob gum contains mannan, about 58 per cent., galactan, about 20 per cent., pentosans, about 3 per cent., proteins, about 5 per cent., cellulose, about 4 per cent., and yields about 0·8 per cent. of ash; an oxydase is present and also an enzyme named ceratonlase. Starch and calcium oxalate are absent.

By boiling 1 per cent. of the powder with water, a viscous slightly opalescent mucilage is formed, which gives no blue colour with solution of iodine. When the mucilage is boiled with 5 per cent. aqueous caustic potash, it becomes clear, but does not develop a yellow colour (distinction from agar and tragacanth) or a brown colour (distinction from sterculia gum).

Uses. Carob gum is used in many preparations in the same way as tragacanth. It also finds a wide use in the food industry for thickening purposes in the place of starch, also for the partial replacement of eggs in salad creams, etc.

SACCHARINE SUBSTANCES

MANNA. Manna

Sources. Manna is strictly a generic term applied to the saccharine exudations from a number of different plants belonging to various natural orders, but, when not otherwise specified, is understood to mean the saccharine exudation from the stem of the manna ash, *Fraxinus ornus* Linn., family Oleaceæ, a small tree widely distributed over southern Europe and cultivated especially in Sicily for the production of manna.

Collection. The t... are about ten years ... day a transverse or ... of the stem; the f... incisions at intervals of ... cm. above the one below, so that finally there is a regular series of such incisions down the whole of one side of the

stem. The exudation flows down the stem and dries or sometimes forms stalactitic masses, but in rainy weather it drops from the trunk and is caught upon cactus cladodes, or upon tiles, placed beneath it, yielding an inferior quality. In the following year the tree is cut upon the opposite side, and in the succeeding year again on the first side. The stem is then exhausted, the tree is cut down, and from the stool two or more shoots are allowed to grow, which in ten years are ready for tapping. As much as 500 gm. of manna may be obtained in a good season from a single stem.

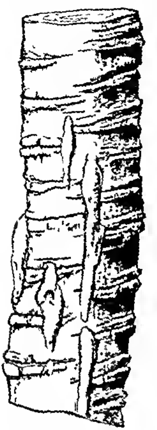

FIG. 187 Portion of the stem of a Manna tree, showing the incisions and adhering manna. Reduced. (Vogl)

Description. The finest qualities of manna, known in commerce as "flake manna," are in pieces about 10 or 15 cm. long and 2 or 3 cm. wide, which are more or less conspicuously three-sided, one of the sides (that which has been next to the stem) being concave and smooth. It is yellowish-white in colour and very brittle, even friable, exhibiting when broken an indistinctly crystalline structure and concentric layering. It has a slight agreeable odour and a sweet taste and is soluble in water. Inferior qualities of manna are of a darker, brownish-yellow colour, and composed of broken flakes agglutinated into a more or less sticky, gummy mass.

Constituents. *Manna consists principally of* mannitol, $C_6H_8(OH)_6$, formerly known as mannite, of which it may contain from 40 to 60 per cent. Mannitol is a crystalline hexahydric alcohol, m.p. 166°, and is widely diffused throughout the vegetable *kingdom*. It is associated in manna with two sugars, viz. mannotriose (6 to 16 per cent.) and mannotetrose (12 to 16 per cent.). Each molecule of mannotriose yields by hydrolysis two molecules of galactose and one of dextrose; each molecule of mannotetrose yields two of galactose and one each *of dextrose and lævulose.* Dextrose, *mucilage,* inorganic substances, a minute quantity of a fluorescent substance, fraxin, and about 10 per cent. of moisture also occur in manna.

Uses. Manna is used medicinally as a gentle laxative.

HONEY. Mel

Sources. Honey is a saccharine fluid made by the hive-bee, *Apis mellifica* Linn., order Hymenoptera, family Apidæ, from the nectar of flowers. In some instances bees collect also other sweet plant juices, such as the honey-dew formed by the agency of aphids from the leaves of trees such as pine, lime and sycamore.

Honey is produced in Britain, but the chief sources of supply are California, Jamaica and Chili.

Preparation and Collection. The nectar of flowers is chiefly an aqueous solution of sucrose. This sweet fluid is sucked by the hive-bee through its proboscis, which is a tubular structure formed by the closely appressed

modified mouth-parts, chiefly the maxillæ, labial palps and the glossa (of the labium) which terminates in a spoon-shaped lobe, termed the labellum. The nectar passes through the œsophagus, which traverses the thorax of the bee and leads to a large honey-sac or honey-stomach which lies in the bee's abdomen. This is separated from the chylo-stomach, in which digestion commences, by the stomach mouth, a valve which controls the passage of fluid from the honey-sac, so that the amount required for the nourishment of the bee is passed on, while the remainder is retained in the honey-sac. The saliva which is mixed with the nectar during its passage to the œsophagus adds the enzyme invertase, which begins to change the

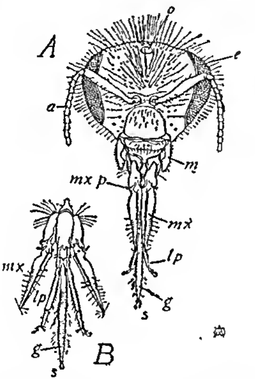

FIG. 188. *Apis mellifica.* *A*, head of a worker bee. *B*, proboscis, showing the constituent parts separated. *a*, antenna; *e*, compound eye; *g*, glossa or tongue; *l.p.*, labial palp; *m*, mandible; *mx*, maxilla; *mx p*, maxillary palp; *o*, ocellus or single eye; *s*, spoon shaped tip All × 8.

sucrose into a mixture of levulose and dextrose. The bee, on returning to the hive, regurgitates the fluid from the honey-sac and deposits it in one of the cells of the comb, where, during the succeeding interval of about three days at the temperature of the hive, it is converted into honey. While this change, termed "ripening," is proceeding the sucrose is converted into levulose and dextrose and a proportion of the water is evaporated. The nectar contains about 75 per cent. of water and 25 per cent. of sucrose and the honey contains about 20 per cent. of moisture and 80 per cent. of invert sugar. When the cell is full, the bees cap it with wax.

To *extract the honey* the capping is removed by the use of a sharp knife which has been warmed in hot water. The combs are then put into a centrifuge and the honey removed. Honey is sometimes removed by pressure, but that necessarily destroys the comb and may lead to the presence of a small amount of wax in the honey.

Description. Honey is a viscid, translucent, nearly white to pale-yellowish or yellowish-brown fluid. It becomes partially crystalline and semi-solid on keeping, owing to the separation of dextrose as crystals. It has an agreeable characteristic odour and a sweet taste, the odour and taste depending upon the nature of the flowers from which the nectar was collected. The specific rotation of honey is from + 3° to — 10°.

Honey obtained from heather and clover is considered to have the finest flavour, while that from species of *Eucalyptus* is the least agreeable.

Constituents. Honey consists chiefly of about 70 to 80 per cent. of a mixture of dextrose and levulose in about equal parts, the residue is chiefly water about 14 to 20 per cent. There are also small amounts of sucrose, about 1·1 to 4·4 per cent., and dextrin, about 0·06 to 1·24 per cent. Large amounts of dextrin, from 9 to 12 per cent., indicate that the bees have collected honey-dew. Quite small amounts of volatile oil, wax and pollen grains are usually present. The ash varies from 0·1 to 0·8 per cent.

A study of the pollen grains occurring in honey gives valuable evidence of the vegetable origin of the honey and frequently also indicates the geographical source.

Uses. Honey is largely used as a demulcent and sweetening agent as well as for its nutritive properties.

Substitutes and Adulterants. The most common adulterants are invert sugar, sucrose and commercial glucose, all of which alter the rotation of the honey. The presence of calcium sulphate, which may be tested for in the usual way either in the honey or in the ash, indicates commercial glucose. Pure honey should show at most a slight turbidity when mixed with three or four volumes of alcohol indicating the absence of dextrin, which is a frequent constituent of commercial glucose and of honey made from honey-dew.

Hydrochloric and sulphuric acids are commonly used for the manufacture of commercial glucose and invert sugar and there should not be more than very small traces present in honey. The presence of invert sugar may also be detected by applying to the ether extract of the honey the test for derivatives of furfuraldehyde, the reagent used being a 1 per cent. solution of resorcinol in hydrochloric acid (s.g. 1·16). This reagent gives a persistent deep cherry-red colour with the traces of furfuraldehyde compounds occurring in the artificial invert sugar.

CHAPTER XVI

RESINS, GUM-RESINS, OLEO-RESINS

RESINS cannot be sharply defined. They form a heterogeneous group, which shows certain well-recognised general characteristics which may be arranged under three headings: (a) Physical characters, (b) behaviour towards solvents, (c) chemical composition and behaviour towards reagents.

Physical Characters. All resins are heavier than water; they are usually amorphous, hard and brittle solids, some are slightly soft semi-solids. By the action of heat they all soften and fuse, yielding clear, adhesive fluids. They burn with a smoky flame.

Behaviour towards Solvents. Resins are insoluble in water and are rarely soluble in light petroleum, in which colophony and dammar are soluble. They are generally more or less soluble in alcohol, ether, acetone, chloroform, carbon disulphide, solution of chloral hydrate, fixed and volatile oils.

Chemical Composition. Resins are complex mixtures of different chemical types of substances; these include acids, esters, glycosidic bodies and indifferent substances classed as resenes. The element nitrogen does not enter into the composition of any resin constituent. Many resins, when boiled with alkalies, yield soaps, which are termed resin soaps Most resins undergo slow change by keeping, they gradually darken in colour and become less soluble, changes which are due to a slow progressive oxidation.

When a certain type of constituent predominates in resins, they are grouped under the heading of that type of constituent, as, for example, "acid resins" and "ester resins." Those resins which have no constituent markedly predominant are grouped under the term "mixed resins."

Classification of Resins

Acid Resins. Predominating constituents are resin acids. Colophony, Burgundy Pitch, Sandarac, Guaiacum.

Ester Resins. Predominating constituents are esters. Benzoin, Dragon's Blood

Mixed Composition. No specially predominant constituent. Mastic, Shellac

Formation of Resins. Natural resins are commonly produced by cells which secrete a fluid composed of substances, one of which is the resin The resin is held in solution by terpenes, volatile oils or esters which are secreted in association with it. These secreting cells may be external and take the form of trichomes of which an account is given on p. 99; a good example is Indian hemp in which the secretion is produced by the

g head

under

or ovoid and multicellular, when they form internal **glands** as in Savin and Clove, or may be tubular and lined with a secreting epithelium, when they form **ducts** as in pine wood and umbelliferous fruits. In many trees the tissue between the oleo-resin ducts breaks down and an anastomosing system of lysigenous cavities is formed; in this case also the cell walls of

the glands of Savin are a good example. A **lysigenous gland** arises as a solid group of cells in which the secretion is produced; the central cells disintegrate, leaving the secretion surrounded by a layer of secreting cells, to which some remains of cell-walls may be attached, as in the glands of

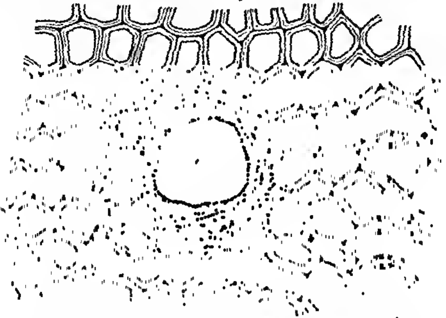

FIG. 189 Transverse section through the wood of *Pinus maritima*, showing an oleo-resin duct, *c*. Magnified. (Tschirch.)

orange peel. In some plants the glands may arise schizogenously and subsequently the epithelium breaks down producing a schizolysigenous or oblito-schizogenous cavity, as may happen in clove. Oleo-resin **ducts**, as found in the umbelliferæ and in the wood and leaf of *Pinus*, arise schizogenously. See also Figs. pp. 150 and 215.

In addition to the secretion ducts normally present in the plant, others may be formed as the result of injury, and, in certain trees, this may also take place even if the plant produces normally no such ducts. The number of the ducts thus formed may be very large and produce large quantities of oleo-resin which, discharged over the wound, forms a temporary protection for it. This flow of oleo-resin, which is termed "secondary flow" to distinguish from the "primary flow" from ducts normally present, is the source of most of the natural oleo-resins of technical importance.

Resin is not always found in special glands or ducts, it may sometimes occur in all the cell elements of a tissue, as in the wood of guaiacum, where all the cells and vessels of the heart-wood become filled with resin. Another method of formation is exemplified by shellac, which is formed from the juices of the plants by the agency of the lac-insect, *Tachardia lacca* R. Blanchard, family Coccidæ.

COLOPHONY. Amber Resin, Resin, Resina. Colophonium

Sources. Colophony is the residue left after the distillation of the oil of turpentine from the crude oleo-resin of various species of *Pinus* (Tourn.) Linn., family Pinaceæ.

The term "common" turpentine is practically restricted to the oleo-resin obtained in America, as the English market is almost exclusively supplied from that source. The bulk is obtained from *Pinus palustris* Miller, the long-leaf pine, but *P. tæda* Linn., the loblolly pine, *P. echinata* Miller, the short-leaf pine, and *P cubensis* Grisebach, the Cuban pine, all yield a considerable quantity. These trees, especially the long leaf pine, form extensive forests in the southern and south-eastern United States, extending from Texas to North Carolina The oleo-resin is secreted in schizogenous ducts occurring chiefly in the wood; see Fig 189

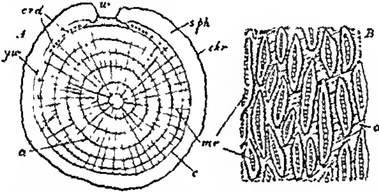

FIG 190 Diagrams of *A* transverse surface of the wounded trunk of a pine tree, and *B* the tangential surface of the youngest wood showing large anastomosing oleo-resin canals *a*, annual rings; *c*, cambium, *ckr*, cork and rhytidoma, *mr*, medullary ray; *or*, oleo-resin, *ord*, oleo-resin duct, *sph*, secondary phloem, *w*, wound, *yw*, youngest wood ring (After Tschirch)

Collection and Preparation. In the winter, while the tree is dormant, a cavity sloping inwards and downwards, termed a "box," is cut near the base of the tree trunk and a certain small amount of oleo-resin collects in it In the following spring cuts are made with an axe to remove the bark from an area above the "box," leaving a V-shaped piece of bark above the "box." The wounds stimulate the formation of numerous new resin-ducts in the youngest wood and from the exposed surface oleo-resin flows into the "box." After eight or ten days the flow slackens and more bark is hacked away higher up, the process being continued until the autumn, when the flow lessens. The last portions exude very slowly and dry on the surface; the incrustation so formed is removed and forms the substance known in America as "scrape" and in England as *Common* or *American Frankincense, Gum Thus* or Thus Americanum.

To avoid the severe damage to the trees occasioned by the cutting of "boxes," it is becoming a common practice to push a piece of tinned iron plate into the base of the wounded area so as to lead the oleo-resin into a metal can attached to the tree trunk just below the iron plate.

After one side of the tree has been drained, the operations are repeated

on the opposite side and then at intermediate positions until the whole tree is exhausted, when it is cut down and is replaced by a young tree.

The crude turpentine is removed by a dipper from the boxes to barrels for transportation to the stills, which are of copper, and are set in brick furnaces. Water is added and the whole warmed, any chips of wood, and other débris, that float to the top being skimmed off. The head is then luted on, and the heat increased. At first, water and oil of turpentine distil over, subsequently oil of turpentine alone. Water is occasionally added to [illegible] After the distillation has been stopped [illegible] wire strainers into barrels and allowed [illegible]

The finest resin is that obtained from the tree in the first year when the crude turpentine yields about 80 per cent. of it. After that, the proportion of oil of turpentine in the oleo-resin gradually diminishes, whilst that of the resin increases, but the latter becomes gradually darker in colour. The resin also becomes darker in colour if it is overheated during preparation and forms common black resin; the finest light-coloured varieties are known as **amber resin.**

The **American oil of turpentine** obtained by this process is usually dextrorotatory, though it may be slightly lævorotatory, and consists chiefly of *d*- and *l*-pinene; its sp. gr. is 0·860 to 0·870 and the refractive index at 25° is 1·465 to 1·480; it distils completely between 156° and 180°.

Description. Colophony, or amber-resin, occurs in irregularly shaped pieces of different sizes formed by breaking up the contents of the barrels in which it has solidified. The pieces are sharply angled with conchoidal surfaces of various sizes; they are pale yellow or brownish-yellow, transparent, brittle and vitreous, and the powder remains [illegible]

1·07 to 1·10 and is insoluble in water. It is soluble in alcohol, ether, chloroform, glacial acetic acid, carbon disulphide, solution of chloral hydrate (5 in 2) and almost completely in light petroleum (b.p. 50° to 60°).

Constituents. American colophony contains about 84 per cent. of total abietic acids, about 5 to 6 per cent. of resene, 0·5 per cent. of volatile oil and traces of a bitter substance. The abietic acids are three unstable crystalline isomeric acids, α, β and γ abietic acids, to which the formula $C_{20}H_{28}O_2$ is assigned. Dufour (1922) considers that these acids are formed from the pimaric acid present in the natural turpentine by the action of heat. The acid value of colophony varies from about 136 to 180 and the saponification value from 157 to 200. Although the saponification value is uniformly higher than the acid value, the resin is nevertheless free from esters.

Colophony may be identified by its high acid value and by the following reactions: 0·05 gm. dissolved in 3 mils of acetic anhydride and cooled gives on the addition of 1 drop of sulphuric acid a purplish-red colour which rapidly changes to violet and finally brown; a solution in light petroleum shaken with a 0·1 per cent. aqueous solution of cupric acetate is coloured bright emerald green (reaction for abietic acid).

Storage. Colophony should be stored in fairly large pieces in

well-closed containers. Powdered colophony gradually loses its solubility in light petroleum as it is kept and it simultaneously increases in weight, the changes being due to oxidation.

Uses. Colophony has stimulant and diuretic properties. It is used chiefly as an ingredient of ointments and plasters.

Bordeaux turpentine is obtained chiefly from the cluster pine, *Pinus pinaster* Ait (= *P. maritima* Poiret), in the south-western departments of Landes and Gironde. A vertical strip of bark, about 5 cm. wide, is cut from the trunk by a narrow-bladed axe and an earthen pot is supported below it to collect the crude turpentine. The operation is repeated at higher levels and the pot gradually raised until the length of the incision is about 3 metres and the wounded area has been exhausted. A fresh incision is now made about one-third of the circumference from the first [illegible]

The resin consists of pimarinic, pimaric, and α- and β-pimarolic acids. The volatile oil, French oil of turpentine, is distinguished from American oil of turpentine by being strongly lævorotatory.

Venice turpentine is obtained from the larch, *Larix europæa* DC., family Pinaceæ, in France, southern Tyrol and northern Italy, by boring into the stem in the spring, and collecting the oleo-resin that exudes. It is a yellowish, slightly turbid, viscid liquid, with bitter aromatic taste. The resinous portion consists chiefly of α- and β-larinolic acids. A factitious mixture made by melting together colophony, linseed oil and turpentine is commonly substituted for it.

Burgundy Pitch. (Pix Burgundica) is an oleo-resin obtained from the stem of the Norway spruce, *Picea excelsa* Link (= *Pinus Abies* Linn, *Abies excelsa* Poiret, the Christmas tree), family Pinaceæ. It is collected chiefly in Finland and to a less extent in the Black Forest and the Jura Mountains. Incisions are made through the bark into the young wood and the secretion of oleo-resin is stimulated. It slowly collects beneath the bark and, after some months, is scraped out from the holes in which it has partially solidified; it is then melted under water and strained. Burgundy pitch occurs in yellowish-brown to dull reddish-brown opaque masses which gradually take the shape of the container; it is more or less tenacious, but becomes brittle on keeping and shows a rough and somewhat dusty surface with conchoidal areas. It has an agreeable aromatic odour and the taste is sweet and aromatic without bitterness. It is soluble in twice its weight of glacial acetic acid.

It contains resin and a little volatile oil. The resin consists of α- and β-piceapimarolic acids, small quantities of piceapimarinic and piceapimaric acids and a resene, named *juro-resene*.

Factitious Burgundy pitch is made by melting together colophony, turpentine, palm oil or some other fat and a little water.

SANDARAC. Gum Juniper, Sandaraca

Sources. Sandarac is a resin obtained from *Tetraclinis articulata* (Vahl.) Masters, family Cupressaceæ, a small tree about 7 metres high, growing on the mountains in the north-west of Africa. It is usually obtained by incision, the tears when sufficiently hard being collected and exported, chiefly from Mogador.

Description. Sandarac occurs in small tears about 5 to 20 mm. long and

2 to 5 mm. thick, more or less cylindrical or stalactitic in form, two or more of which are sometimes united into a small, flattened mass; globular or pear-shaped tears are few in number. The tears have a dull, dusty surface and a pale yellowish colour; they are brittle, breaking with a glassy conchoidal fracture, and exhibiting a clear, transparent interior, in which small insects are occasionally embedded. The resin has a slight terebinthinate odour and a terebinthinate, slightly bitter taste; when chewed it breaks up between the teeth into a sandy [illegible] ch, unlike mastich, *shows no disposition to* [illegible]

It is completely soluble in [illegible] in ether, partially only in chloroform, ca[illegible] turpentine and light petroleum.

Constituents. Sandarac consists of resin associated with traces of volatile oil, bitter principle, etc. The chief constituent of the resin is (optically) inactive pimaric acid (85 per cent.), obtainable in acicular crystals melting at 170°; other constituents are sandaracinic acid (2 per cent.), amorphous callitrolic acid (10 per cent.), and sandaracoresene. Callitrolic acid is easily converted into the lactone which is insoluble in alcohol.

Uses. Sandarac *is chiefly used in the manufacture of varnishes; it is* paler in colour than shellac, and is therefore more suitable for light woods. It is good resin for making permanent microscopical preparations.

Substitute. *Australian sandarac, from C. verrucosa* Robert Brown, *is* occasionally imported. The tears are softer, larger, and more aromatic than those of African sandarac, which it otherwise resembles. Its composition is similar, but it contains more volatile oil and more inactive pimaric acid

GUAIACUM RESIN. Resina Guaiaci

Source, etc. Guaiacum resin is the resin obtained from the stem of *Guaiacum officinale* Linn., or *Guaiacum sanctum* Linn., family Zygophyllaceæ.

Preparation. The bulk of the resin of commerce is produced in the following rather crude way from the trunk of the tree, the heartwood of which contains from 20 to 25 per cent. of resin: A log of the wood is supported in a horizontal position above the ground by two upright bars. Each end of the log is then set on fire, and, a large incision having been previously made in the middle, the melted resin runs out therefrom in considerable abundance ("Pharmacographia"); or one end of a log of wood is raised, and fire applied to it, when the melted resin will run out of a groove cut in the other end, and may be received in potsherds (block resin). The resin may also be obtained in the form of tears by incisions made into the trunk, but the tear resin of commerce is certainly not so produced; probably it consists of the last runnings of the melted resin which solidify in the form of tears. The resin is also prepared by extracting the wood with alcohol.

Description. Guaiacum resin is usually seen in large masses of dark colour, often more or less covered with a greenish powder. The resin breaks easily with a clean, glassy fracture, thin splinters viewed by transmitted light being transparent, and varying in colour from yellowish-green to reddish-brown. The powder is greyish, but becomes green by exposure to light and air. It has a slightly acrid taste, and, especially when warmed, a somewhat balsamic odour. It is freely soluble in alcohol, chloroform, and solution of caustic potash, incompletely in ether, and only slightly soluble in petroleum spirit, carbon disulphide, or benzene.

The resin in tears occurs in rounded masses, 2 to 3 cm. in diameter,

usually covered with a greenish powder, and exhibiting the characters already detailed.

The commercial drug is never completely soluble in alcohol. The residue, which in the case of tear resin is about 1·5 per cent., and in good samples of the lump averages about 7·5 per cent. and should not exceed 10 per cent., in exceptional cases, however, it may amount to as much as 25 per cent. It consists chiefly of vegetable débris, gum, etc.

Constituents. Guaiacum resin consists chiefly of α- and β-guaiaconic acids, about 70 per cent., guaiaretic acid, about 11.25 per cent., and a small amount of guaiacic acid. Other constituents are guaiac-β-resin, about 15 per cent., guaiac yellow, vanillin and guaiac-saponin.

α-Guaiaconic acid is a colourless amorphous substance, probably a mixture, one constituent of which is changed by oxidising agents to deep blue guaiac-blue. β-Guaiaconic acid is colourless and crystalline. Guaiaretic acid is light brown, amorphous, and insoluble in ether. Guaiac-β-resin is brown and amorphous, and appears to be chiefly a decomposition product of the guaiaconic acids; it contains the substance that yields guaiac-blue by oxidation.

Guaiacum resin is easily identified by its reaction with oxidising agents. This is best seen by dissolving a little of the resin in alcohol and adding a drop of dilute solution of ferric chloride; the liquid instantly assumes a deep blue colour which is destroyed by reducing agents, but restored by oxidising agents.

Uses. The action of guaiacum is that of a local stimulant or, in large doses, irritant. It has been employed locally in the form of a lozenge, and has also been given in chronic gout and rheumatism. In the form of tincture, it is used for the detection of oxidases.

BENZOIN. Benzoinum

Benzoin occurs in several well-defined commercial varieties, one of which, Sumatra benzoin, is the most valued medicinally.

The trees from which benzoin is obtained do not contain any special secreting cells or ducts, and normally produce no benzoin; the drug is therefore a pathological product, the formation of which is induced by injury to the tree.

Sumatra Benzoin

Sources. Sumatra benzoin is obtained from *Styrax Benzoin* Dryander and *S. paralleloneurus*, family Styraceæ, trees indigenous to and cultivated in Sumatra. After the infliction of injury the cambium rapidly produces new wood, in which a ring (or sometimes two rings) of oleo-resin ducts are formed. By the breaking down of the tissue between the ducts large schizolysigenous canals are produced, the oleo-resin from which flows over the wounded surface. Similar ducts are also formed in the bark.

Collection and Preparation. West Sumatra benzoin is prepared from *S. paralleloneurus* and *S. Benzoin* (Brans, 1933) as follows:—

When about seven to ten years old the trees are tapped for resin by making in a horizontal plane, at about 40 cm. above the base, three equidistant, triangular, gaping wounds, and 40 cm. above each of these a second and a third series. After about a week a yellowish sap begins to exude, which is subsequently removed in the form of an amorphous mass which is not utilised; the subsequent flow is white and viscous. A new incision is now made 4 cm. above each of these original ones and an additional

series of three 40 cm. above the height of the original three series. This treatment continues until lines of incisions have been made and exhausted, other lines of incisions are now started at intermediate positions between the first lines. The outer part of the hardened white exudation is first collected; this is the finest quality and forms the "almonds" of the benzoin. Later collections taken nearer to the bark are darker in colour and yield second and third qualities. Each of these qualities is at first kept separate, but they are subsequently, at the export town (Palembang), mixed in definite proportions, softened in the sun and stamped together into solid masses. In this way three varieties of benzoin are obtained, varying in the proportion of white "almonds" to brown matrix and in

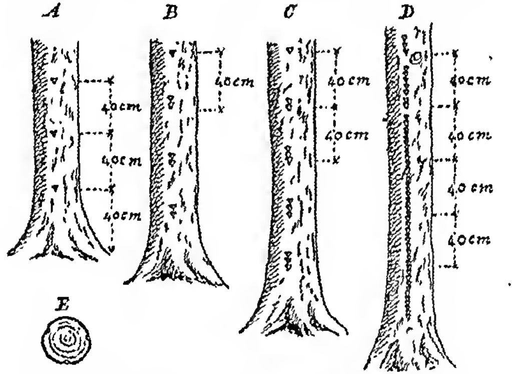

FIG. 191. Benzoin. *A*, first incisions. *B*, one and half to two months after *A*. *C*, three months after *B*. *D*, twenty-four months after *B*. *E*, section of tree showing the three positions on the circumference where the first rows of incisions are made. (After Reinitzer.)

the proportion of fragments of bark they contain. A single tree will yield about 10 kilos per year and becomes completely exhausted about the seventeenth to the nineteenth year. (Reinitzer, 1926.)

Description. Sumatra benzoin occurs in masses consisting of opaque, creamy white tears embedded in a dull, greyish-brown, or sometimes reddish-brown matrix. It is hard and brittle and the fractured surface is dull and uneven. It possesses an agreeable, balsamic odour, recalling storax, and a slightly acrid taste. When cautiously heated it melts and evolves whitish irritating fumes of benzoic and cinnamic acids. When a little of the crushed resin is warmed with dilute sulphuric acid and potassium permanganate benzaldehyde is evolved, indicating the presence of more than traces of cinnamic acid in the drug.

Sumatra benzoin is frequently contaminated with pieces of bark and other débris, especially in the angles and round the sides of the box in which it is packed.

Good Sumatra benzoin should not contain more than 20 per cent. of substances insoluble in alcohol; inferior qualities often yield up to 30 per cent.; on incineration, it should not leave more than 2 per cent. of ash.

Constituents. Sumatra benzoin consists principally of esters of cinnamic and benzoic acids associated with the free acids. The alcohols with which the acids are combined in the form of esters are benzoresinol (probably identical with the siaresinol of Siam benzoin), and probably coniferyl alcohol associated with oxidation products of the latter. The drug contains, in addition, traces of benzaldehyde, vanillin (1 per cent.), phenylpropyl cinnamate, styrol (phenylethylene), and styracin (cinnamylcinnamate), all of which combine to produce its particular fragrance.

fre

cir

6·5 and combined benzoic acid 2·5 per cent.

Siam Benzoin

Sources. This variety of benzoin is collected in the Siamese province

of the Mekong River, from

tree does not yield benzoin

1,600 metres and is properly

tapped.

Collection. How the tapping is effected is not definitely known, but

bark is loosened by a preliminary beating.

Description. Siam benzoin occurs in commerce either as separate tears

glassy, reddish-brown, transparent or translucent resin, which gives the surface a peculiar varnished appearance In this case also the proportion of the red, transparent resin increases as the drug is kept until it becomes its most prominent feature

Both varieties of Siam benzoin are characterised by their agreeable fragrant odour, recalling vanilla; they are almost entirely soluble in

powder, [illegible]

[illegible]

Constituents. [illegible] composition :—

α- and β-Ma[illegible] acids, amorphous, soluble in alcohol	38·0 per cent.
α-Mast[illegible]	30·0 ,,
[illegible]	20·0 ,,
[illegible]	4·0 ,,
Volatile oil	2·0 ,,
Masticolic acid, crystalline	0·5 ,,

It consists therefore chiefly of resin acids and resenes associated with about 2 per cent. of volatile oil (chiefly *d*-pinene).

Uses. Mastich was formerly employed as a stimulant, and was also used in the manufacture of varnishes. For the latter purpose it has been superseded by other cheaper resins; it is, however, used for making a surgical varnish.

Substitutes. Bombay mastich is [illegible] probably other species) ; it [illegible] 109), which is much higher than [illegible] Indian mastic is from *P. cabulica* and Pistachio mastic from *P. terebinthus*.

GUM-RESINS

The gum-resins consist, as their name indicates, chiefly at least of resin and gum. With these constituents, however, there are always associated small quantities of other substances such as volatile oil, bitter principle, enzyme, etc. They are secreted either in schizogenous or schizolysigenous ducts or in secretion cells ; in the former case they are formed in the epithelial cells, and discharged into the ducts in the form of milky liquids which exude when the ducts are punctured.

The resins contained in the gum-resins exhibit in general the characters detailed on pp. 415–417.

The gum of most of the gum-resins resembles, but is not identical with, acacia gum ; very possibly it may consist of two or more glycosidal acids in varying proportions. It is always accompanied by an enzyme from which it has never yet been freed ; it therefore always contains traces of nitrogen.

GAMBOGE. Cambogia

Sources. Gamboge is a gum-resin obtained from *Garcinia Hanburii* Hooker filius, family Guttiferæ, a tree of moderate size found in Cambodia, Siam, and the southern parts of Cochin China.

Collection. The bark of the tree contains in the cortex, as well as in the phloem, secretory ducts filled with a yellow, resinous emulsion, the two systems of ducts being connected by transverse canals at the nodes.

The gamboge is obtained by making, in the rainy season, a spiral cut in the bark from the height of about 3 metres down to the ground. The emulsion wells out and trickles down the incision into a hollow bamboo placed to receive it. From this it is transferred to smaller bamboos ; these are set aside until, in about a month, the gamboge has solidified.

It is removed from the bamboo by drying over a fire until the bamboo cracks and can be stripped off. The drug is sold to local collectors, who convey it to Bangkok or Saigon, whence it is exported to Europe, usually *viâ* Singapore.

It is occasionally formed whilst soft into cakes of various shapes or into thick sausage-lik [illegible]
which they bear [illegible]

Description. [illegible]
in thickness, an [illegible]
hollow in the centre, and marked externally with longitudinal striations derived from the inner surface of the bamboos in which they have been dried. The drug breaks easily, with a smooth, uniform, conchoidal fracture, the freshly fractured surface having a dull gloss and being of a rich reddish-yellow or brownish-orange colour. It is easily reduced to a bright yellow powder, with little odour, but with an acrid taste.

Microscopy. Thin splinters mounted in oil exhibit a ground-mass of gum in which numerous minute granules of resin are scattered accompanied by occasional crystals of calcium oxalate and starch grains derived from the incised tissues.

Constituents. Gamboge consists essentially of a mixture of 70 to 80 per cent. of resin with 15 to 25 per cent. of gum.

The resin, formerly known as cambogic acid, is soluble in alcohol, ether, chloroform, benzene, petroleum spirit, etc., as well as in solutions of alkaline hydroxides and carbonates; from its alkaline solutions it is precipitated by acids. From it three acids have been separated, viz., α-, β- and γ-garcinolic acids, the last named being characterised by the red colour of even a very dilute alkaline solution. The gum is analogous to acacia gum; it is lævorotatory and contains an oxydase enzyme.

[illegible]

colour.

Lump or *cake gamboge* consists of pipe gamboge bent and pressed whilst soft so as to form a cake; or it may occur in irregular lumps which are frequently soft in the interior and often contain abundant visible impurity in the shape of sand, small stones, etc.

Saigon gamboge is occasionally exported from Saigon in short, thick, cylindrical cakes wrapped in palm leaves.

Uses. Gamboge produces purging and in large doses vomiting. It has been employed as a hydragogue cathartic, but is now seldom used as a medicine.

Adulterants. The chief adulterants are starch, inorganic matter (such as sand, etc.), and vegetable débris. These are all easily detected by their [illegible]

MYRRH. Myrrha

Sources. Myrrh is a gum-resin [illegible]
molmol, Eng[illegible]
collected ch[illegible]

Constituents. The white tears of Siam benzoin are crystalline and consist chiefly of coniferyl benzoate. When warmed to about 50° the white tears become yellow, red and brown and lose their crystalline

Further constituents are vanillin and an oily aromatic liquid, probably an ester of benzoic acid. Siam benzoin contains about 39 per cent. of total aromatic acids (about 23 per cent. free and 16 per cent. combined), 36 per cent. being benzoic acid and 3 per cent. cinnamic acid (Cocking and Kettle, 1914). This proportion of cinnamic acid is so small that it cannot be detected by heating with solution of potassium permanganate.

Penang Benzoin

Two distinct varieties of benzoin from Sumatra have been known under this name. They are derived from *Styrax subdenticulata* and *S. subpaniculata*. The one, now generally termed storax-benzoin, has a very agreeable odour resembling storax; the other, known as "glassy Penang" or simply "Penang" benzoin, is distinguished by its glistening glassy fracture and slight odour. Both varieties are packed like Sumatra benzoin.

Palembang Benzoin

This variety, which is not official, is produced in Sumatra, solely from *S. Benzoin*. It is commonly imported in tins, four of which are packed in a wooden case. It differs markedly in appearance from both Siam and Sumatra benzoins, consisting principally of a translucent, greyish-brown or reddish resinous mass in which a few scattered, opaque, white tears are embedded. It breaks with an irregular fracture, the fractured surface being uneven and often exhibiting small cavities. The odour, which is not strong, recalls that of Sumatra benzoin. Its constituents have not yet been accurately investigated. It is used for the preparation of benzoic acid.

Uses. Benzoin taken internally acts as a carminative expectorant and diuretic; externally it is stimulant and antiseptic.

DRAGON'S BLOOD. Sanguis Draconis

Sources. Dragon's blood is a resinous secretion from the fruits of *Dæmonorops propinquus* Beccari, *D. ruber* Martius, and probably other species. The two species named were formerly included in *Calamus Draco* Willdenow, family Palmæ; they are climbing palms with long, flexible stems, and are indigenous to Sumatra and Borneo.

Collection. The plant produces numerous small fruits about the size of a cherry, covered with hard, yellowish, imbricated scales, which overlap one another from apex to base. From between these scales a red resin, probably produced in the pulp of the fruit, exudes and more or less completely encrusts the fruit. The fruits are beaten and shaken together in sacks or baskets, and the separated resin mixed with water, pressed into moulds, and then melted; or it is made into a cake which is wrapped in a cloth, steeped in hot water and pressed to form a solid block. It is said to be nearly always mixed with the milky juice of *Garcinia parviflora*, Miquel (Treub, 1891).

Description. Dragon's blood occurs in lumps of very varying size and
ighing several
they may be
out 5 cm. in
thickness. Occasionally it is imported in sticks about 20 to 25 cm. long

and 2 to 3 cm. thick or 30 cm long and 1·5 cm. thick, each carefully

These varieties are known as

blood.

dull, dark red colour, and are more or less covered, where the pieces have rubbed against one another, with a crimson powder. They are brittle and friable, breaking with a glossy but irregular, uneven fracture, minute fragments being translucent and of a deep garnet-red colour.

The drug yields when crushed a bright crimson powder, has no odour and is practically tasteless, breaking up when chewed into a fine gritty powder.

Tears, in which form the drug is now seldom seen, give a glassy, conchoidal fracture, thin flakes being of a clear garnet-red colour.

Constituents. Dragon's blood consists principally of a red resin (57 per cent.), a compound of dracoresinotannol (a resin-alcohol) with benzoic and benzoylacetic acids. Other constituents are white, amorphous dracoalban (2·5 per cent.), yellow dracoresene (14 per cent.), vegetable débris (18·4 per cent.), and ash (8 3 per cent.).

fragments seldom exceeding 2 cm. in length with a vitreous fracture, thin splinters being of a ruby red colour. It does not evolve an odour of benzoic acid when heated, and contains no scales similar to those found in Sumatra dragon's blood.

MASTICH. Mastiche

Sources. Mastich is a resin obtained from a broad-leaved variety of *Pistacia lentiscus* Linn., family Anacardiaceæ, a shrub or small tree indigenous to the countries bordering on the Mediterranean. The resin which has been known from the earliest times, and was formerly much more highly prized than it is now, is collected on the island of Scio in the Grecian Archipelago, and also in Cyprus, and possibly on other islands, but is exported only from Scio.

Collection. The bark of the tree, which contains a circle of oleo-resin ducts in the phloem, is punctured with a small instrument resembling a

is inferior.

Description. Mastich [illegible] ovoid, or nearly globular, [illegible] not often, they are elong[illegible]

d quite

llow in

with a

g quite

transparent. When chewed the tears break up at first into a sandy

powder, which subsequently agglomerates into a plastic mass. The drug [illegible]

[illegible]

α- and β-Masticonic acids, amorphous, soluble in alcohol	38·0 per cent.
α-Masticoresene, soluble in alcohol	30·0 ,,
β-Masticoresene, insoluble in alcohol	20·0 ,,
α- and β-Masticinic acids	4·0 ,,
Volatile oil	2·0 ,,
Masticolic acid, crystalline	0·5 ,,

It consists therefore chiefly of resin acids and resenes associated with about 2 per cent. of volatile oil (chiefly d-pinene).

Uses. Mastich was formerly employed as a stimulant, and was also used in the manufacture of varnishes. For the latter purpose it has been superseded by other cheaper resins; it is, however, used for making a surgical varnish.

Substitutes. Bombay mastich is obtained from *P. Khinjuk* Stokes (and probably other species); it is darker than genuine mastich, less vitreous, more soluble in alcohol and less soluble in oil of turpentine. It may also be distinguished by the acid value (103 to 109), which is much higher than that of genuine mastich (45 to 67). Indian mastic is from *P. cabulica* and Pistachio mastic from *P. terebinthus.*

GUM-RESINS

The gum-resins consist, as their name indicates, chiefly at least of resin and gum. With these constituents, however, there are always associated small quantities of other substances such as volatile oil, bitter principle, enzyme, etc. They are secreted either in schizogenous or schizolysigenous ducts or in secretion cells; in the former case they are formed in the epithelial cells, and discharged into the ducts in the form of milky liquids which exude when the ducts are punctured.

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GAMBOGE. Cambogia

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Collection. The bark of the tree contains in the cortex, as well as in the phloem, secretory ducts filled with a yellow, resinous emulsion, the two systems of ducts being connected by transverse canals at the nodes.

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It is removed from the bamboo by drying over a fire until the bamboo cracks and can be stripped off. The drug is sold to local collectors, who convey it to Bangkok or Saigon, whence it is exported to Europe, usually *viâ* Singapore.

It is occasionally formed whilst soft into cakes of various shapes or into thick sausage-like masses, which are wrapped in leaves, the impression of which they bear on their surface (Saigon gamboge).

Description. The finest qualities of gamboge occur in rolls, 3 to 5 cm. in thickness, and from 10 to 20 cm. in length, nearly cylindrical, solid or hollow in the centre, and marked externally with longitudinal striations derived from the inner surface of the bamboos in which they have been dried. The drug breaks easily, with a smooth, uniform, conchoidal fracture, the freshly fractured surface having a dull gloss and being of a rich reddish-yellow or brownish-orange colour. It is easily reduced to a bright yellow powder, with little odour, but with an acrid taste.

Microscopy. Thin splinters mounted in oil exhibit a ground-mass of gum in which numerous minute granules of resin are scattered accompanied by occasional crystals of calcium oxalate and starch grains derived from the incised tissues

Constituents. Gamboge consists essentially of a mixture of 70 to 80 per cent. of resin with 15 to 25 per cent. of gum.

The resin, formerly known as cambogic acid, is soluble in alcohol, ether, chloroform, benzene, petroleum spirit, etc., as well as in solutions of alkaline hydroxides and carbonates; from its alkaline solutions it is precipitated by acids. From it three acids have been separated, viz., α-, β- and γ-garcinolic acids, the last named being characterised by the red colour of even a very dilute alkaline solution. The gum is analogous to acacia gum; it is lævorotatory and contains an oxydase enzyme.

Rubbed with the wet finger gamboge instantly forms a yellow emulsion. It is almost completely dissolved by the successive action of alcohol and water. The yellow emulsion yielded with water becomes nearly clear and deep orange-red on the addition of ammonia.

Varieties. *Pipe gamboge*, as above described, is the best variety.

Inferior gamboge breaks with a dull, rough, granular fracture, and the fractured surface, which often exhibits small cavities, is of a dark brownish colour.

Lump or cake gamboge consists of pipe gamboge bent and pressed whilst soft so as to form a cake; or it may occur in irregular lumps which are frequently soft in the interior and often contain abundant visible impurity in the shape of sand, small stones, etc.

Saigon gamboge is occasionally exported from Saigon in short, thick, cylindrical cakes wrapped in palm leaves.

Uses. Gamboge produces purging and in large doses vomiting. It has been employed as a hydragogue cathartic, but is now seldom used as a medicine.

Adulterants. The chief adulterants are starch, inorganic matter (such as sand, etc.), and vegetable débris. These are all easily detected by their insolubility in alcohol and water used successively or in dilute ammonia.

Indian gamboge is obtained in India from *G. morella* Desrousseaux, and resembles Siam gamboge in its essential qualities; it is used as an equivalent of gamboge in India and the Eastern Colonies.

MYRRH. Myrrha

Sources. Myrrh is a gum-resin obtained from the stem of *Commiphora molmol*, Engler, and probably other species, family Burseraceæ. It is collected chiefly in Somaliland (in the north-east of Africa), brought

down to the coast and sent to Aden, whence it is shipped to Europe, either direct or *viâ* Bombay. Some myrrh is said also to be collected in the south of Arabia.

Collection. Schizogenous ducts in the bark become enlarged by the breaking down of the surrounding cells to form large lysigenous cavities in which a granular oleo-gum-resin collects. When the bark is wounded, the secretion exudes and changes in the air from a yellowish-white fluid

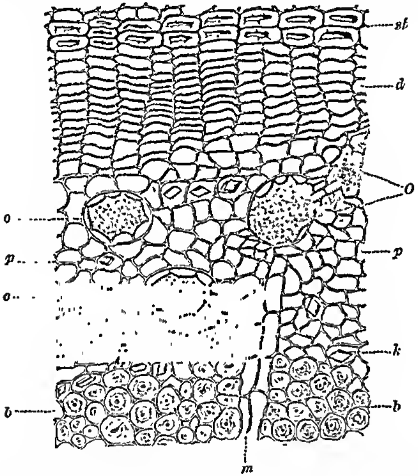

FIG. 192. Myrrh. Section of a portion of bark, probably of *Commiphora molmol* P, outer portion in which layers of sclerenchymatous cells, *st*, alternate with thin-walled cells, *d*; *p*, phloem parenchyma; *b*, sclerenchymatous fibres; *m*, medullary ray; *o*, oleo-resin ducts containing a granular secretion (myrrh); *O*, tissue breaking down to form a cavity filled with the secretion. Magnified 280 diam. (Vogl.)

to a reddish-brown hard mass, which is myrrh. The greater part of the gum-resin exudes spontaneously through natural fissures. The gum-resin is collected by the Somalis chiefly on the high plateaux of the interior. They also collect perfumed myrrh or bissabol and a variety of gum acacia, the three commodities being put into separate bags made of goat-skins. The produce is taken down to the coast to the great fair at Berbera on the Gulf of Aden (November to February) where it is bought by traders from India who ship it to Bombay, where it is picked over by hand to remove impurities; it is then exported to Europe. Some myrrh is taken to Aden, whence it is shipped either to Bombay or direct to Europe.

Description. Myrrh occurs in irregular rounded tears or in masses of agglutinated tears about 2·5 cm. in diameter, sometimes as much as 10 cm. across. The pieces are reddish-brown with a rough, dull and dusty surface ; they are brittle and break with a granular fracture, the exposed surface being unctuous and often marked by whitish spots or veins ; thin splinters are translucent or almost transparent The drug has an agreeable aromatic odour and an aromatic, bitter and acrid, but not unpleasant taste. Triturated with water it yields a yellowish emulsion.

Constituents. Myrrh consists of a mixture of resin, about 25 to 35 per cent , volatile oil, about 2·5 to 6·5 per cent., the remainder of the drug consisting of gum, moisture, and various impurities.

Alcohol dissolves the volatile oil and resin. The volatile oil is yellowish and viscous and resinifies with great rapidity. The resin is not entirely soluble in ether. The insoluble (smaller) portion contains α- and β-heerabomyrrholic acids and the portion which is soluble in ether contains three free resin acids, α-, β- and γ-commiphoric acids, esters of a resin acid, commiphorinic acid, and two phenolic resins, α- and β-heerabomyrrhol (Friederick, 1907). These constituents differ markedly from substances isolated from other resins. If myrrh is extracted with ether and the solution is allowed to evaporate, it leaves a thin film upon the dish and this is immediately coloured deep violet by the vapour of bromine or the fumes from nitric acid. Both the volatile oil and the resin give this reaction.

The gum is apparently allied to acacia gum ; it yields by hydrolysis arabinose and contains an oxydase enzyme the activity of which is destroyed by a temperature (*in solution*) of 100°, but not of 90°.

The bitter principle has not yet been isolated.

Good myrrh should yield not more than 70 per cent. of substances insoluble in alcohol and not more than 5 per cent. of ash , commercial powdered myrrh often yields much more ash

Uses. Myrrh has stimulant and antiseptic properties ; it is used as a mouth wash and as a uterine stimulant and emmenagogue

Substitutes and Adulterants. In addition to Somali myrrh as above described, the following varieties occur in commerce :—

Fadhli or *Arabian myrrh*, which occurs in smaller pieces made up of agglutinated tears, presenting a less dusty surface, and free from white markings The odour is less fragrant and taste less bitter than that of genuine myrrh. It is said to be collected on the mountains to the east of Aden.

Yemen myrrh, which occurs in large pieces of dark reddish-brown colour and dusty surface. It exhibits no whitish streaks and exudes no oil. The taste is bitter ; the odour resembles that of myrrh, but is less aromatic. It is exported from Makullah to Bombay and Aden.

Perfumed bdellium or *bissabol*, which closely resembles myrrh and comes from Ogaden. It breaks with a waxy fracture and yields to the nail, giving an oily exudation like soft myrrh. It has a yellowish colour and exhibits white markings, which, however, are traversed by angular interstices filled with a brown resin. It has a taste and odour quite distinct from those of myrrh, and it does not yield the violet reaction. It is frequently seen in the London market, where it is offered for sale under various names (*scented bdellium*). It is probably derived from *C erythræa*, var. *glabrescens* Engler.

Opaque bdellium, a very hard, yellowish-brown opaque gum-resin with but a slight odour and a bitter taste. Portions of a papery bark are frequently found associated with it. The tincture (1 in 6) assumes an intense greenish-black colour with solution of ferric chloride.

African bdellium, in hard pieces, translucent in thin layers, and red when viewed by transmitted light. The fracture is dull and slaty, the margins possessing a powdery appearance; it has a bitter taste and an odour recalling pepper. The tincture gives no precipitate with ferric chloride.

Indian bdellium, which occurs in large irregular masses of a dark reddish-brown colour. The fractured surface resists the nail, and is covered with characteristic, minute, shiny points of resin which also appear on the outer surface. The odour is feeble and cedar-like; it appears to be developed only on keeping. The taste is slightly acrid and devoid of bitterness.

Gum hotai, liver-coloured, opaque masses, is sent in large quantities to Bombay It contains an acid resin and a saponin and is used for washing the hair.

OLIBANUM. Frankincense

Sources. Olibanum or frankincense (to be carefully distinguished from American frankincense) is a gum-resin obtained from *Boswellia Carterii* Birdwood, and possibly other species of *Boswellia*, family Burseraceæ.

Collection. These plants are small trees that grow in southern Arabia and in Somaliland, near the coast. Like the trees that yield myrrh, they contain schizogenous ducts in the bark, in which an oleo-resin is secreted. The Somalis incise the bark and collect the gum-resin as soon as it has sufficiently dried. The drug is conveyed to Aden, sorted, and exported to Europe.

Description. Olibanum occurs in small tears varying from 0·5 to 3 cm. in length and usually ovoid, pear-shaped, or club-shaped, but sometimes stalactitic in form, occasionally agglutinated into small masses. They are usually of a pale yellowish colour, frequently with a greenish, bluish, or reddish tinge, semi-translucent and covered with a dull white dust, the surface of the tear being dull even after the dust has been removed. They are brittle, and internally are opalescent and translucent, the fractured surface being dull and waxy. The drug has a fragrant, balsamic odour and an aromatic, slightly bitter taste, and softens to a plastic mass when chewed. Triturated with water it yields a whitish emulsion.

Constituents. Olibanum consists principally of resin (60 to 70 per cent.), gum (27 to 35 per cent.), and volatile oil (5 to 7 per cent.).

These constituents have been further investigated, with the following results (Halbey, 1898):

Soluble in alcohol, 72 per cent.	Boswellic acid, free	33·0 per cent.
	„ „ combined	1·5 „
	Olibanoresene	33 0 „
	Volatile oil	7·0 „
	Bitter principle	0·5 „
Insoluble in alcohol, 28 per cent.	Gum (arabic acid with Ca and Mg)	20·0 „
	Bassorin	6 0 „
	Vegetable débris	2·0 „

The volatile oil is yellowish and fragrant; it contains pinene, dipentene, and phellandrene, but the aromatic constituent is not yet known.

Uses. Olibanum is used chiefly in the manufacture of incense and as an ingredient in plasters and fumigating pastilles.

AMMONIACUM. Ammoniacum

Sources. Ammoniacum is a gum-resin exuded from the flowering and fruiting stem of *Dorema ammoniacum*, D. Don, family Umbelliferæ, and probably other species, distributed throughout Persia and extending into southern Siberia. The drug is collected chiefly in central Persia.

Collection. The stems of the ammoniacum plants contain, especially in the cortex, numerous, large, schizogenous ducts full of a milky secretion. In the summer, when the plant is fruiting, it is visited by numbers of beetles, which puncture the stem and cause an abundant exudation of the secretion in the form of milky drops, some of which harden on the stem, whilst others drop on to the ground. It is collected, sorted, and exported from the Persian Gulf ports.

Description. Ammoniacum occurs in commerce in two forms—viz. *tear ammoniacum* and *lump ammoniacum*

The *tears* are small, rounded or nodular masses varying usually from 0·5 to 3 cm. in diameter. When fresh they are of a pale, dull yellow colour, which, however, darkens by keeping They are hard and brittle when cold, but soften when warmed. Internally the tears are opaque, and vary in colour from milky-white to pale brownish-yellow, the freshly fractured surface having a waxy lustre. The drug has a characteristic but not alliaceous odour, and a bitter, acrid taste Triturated with water it forms a white emulsion, which is coloured deep orange-red by a solution of chlorinated soda, yellow by solution of potash, and, *transiently*, faintly violet by ferric chloride, owing to the presence of traces of free salicylic acid

Lump ammoniacum consists of agglutinated, whitish, yellowish-grey or bluish-grey tears, mixed with varying quantities of extraneous substances, such as stones, dirt, stems and other débris of the plant and occasionally the broad, flat mericarps of the fruit, the presence of which indicates the time at which the drug was collected. The substance of the tears agrees with the description of the tears already given. Good qualities consist of tears varying in size from a pea to a hazel-nut or even larger, with a little intervening dark-coloured ground substance, and but few pieces of stem, fruits, etc Intermediate forms composed of more or less agglutinated tears also occur.

Constituents. Ammoniacum consists of volatile oil (0·1 to 1·0 per cent.), resin (about 65 to 70 per cent.), gum (about 20 per cent.), moisture (2 to 12 per cent), ash (1 per cent), and insoluble residue (3·5 per cent).

The resin contains about 20 per cent. of resene and an ester composed of ammoresinotannol combined with salicylic acid (Luz, 1893). Casparis (1924), however, finds the main constituent to be a phenolic resin, ammoresinol, which was obtained in colourless crystals, m p. 110°, and is the cause of the orange-red colour given with chlorinated soda. The gum is allied to gum acacia. Both free and combined umbelliferone are absent from ammoniacum.

The drug contains also traces of free salicylic acid. Good qualities yield about 3 per cent. of ash and 65 per cent. of resin

Uses. Ammoniacum is a stimulant, and, being excreted by the bronchial mucous surfaces, stimulates and disinfects the secretion. It is used as a disinfectant expectorant in chronic bronchitis with profuse discharge, and in plasters as a stimulant to the skin.

Substitute. Persian ammoniacum is distinguished from African ammoniacum, said to be obtained in Africa from *Ferula communis* Linn., var. *brevifolia*, by the orange-red colour it yields with solution of chlorinated soda, and also by yielding a negative result with the tests for umbelliferone.

GALBANUM. **Galbanum**

Source, etc. Galbanum is a gum-resin obtained from *Ferula galbaniflua* Boissier and Buhse, family **Umbelliferæ**, and probably from other species of *Ferula*.

These plants are, like those yielding ammoniacum, large umbelliferous

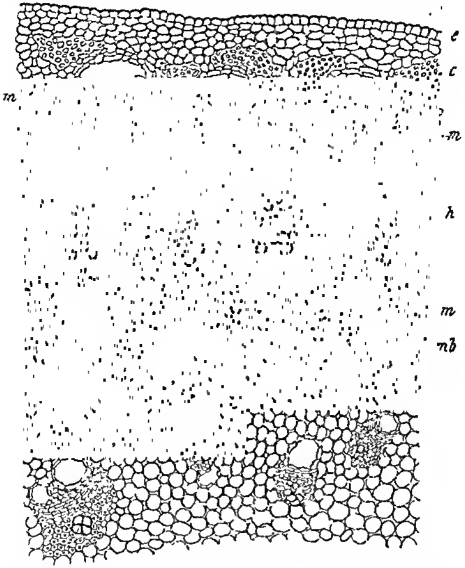

FIG. 193. Transverse section through a portion of the stem of *Ferula galbaniflua*, showing the distribution and structure of the gum-resin ducts. *e*, epidermis; *c*, collenchyma; *m*, gum-resin ducts; *h*, wood; *mb*, bundles in pith; magnified. (Tschirch.)

plants indigenous to and widely distributed over Persia. Two varieties at least of the drug are well recognised—viz. Persian, which is soft and contains fruit and stalks; and Levant, which is dried and contains slices of the root, seldom fruit or stalks. The latter is the variety at present usually met with.

Collection. Like the ammoniacum plants, the galbanum plants contain, especially in the cortical portion of the stem and root, numerous schizogenous ducts that secrete a milky gum-resinous fluid.

Part of the drug is apparently obtained by natural exudation from the stem, but part is certainly produced by laying bare the root, cutting the stem off near the crown, and collecting the juice that exudes and hardens, successive slices of root being removed at intervals of several days. The former procedure would probably yield the tears that are found in commercial galbanum, whilst the slices of root found in the drug indicate the latter method as the one by which most of the drug is obtained. It is exported chiefly from the Persian Gulf ports.

Description. *Tears* of galbanum are rounded or irregular in form, and about 0·5 to 1·0 cm in diameter. Externally they are yellowish-brown or orange-brown in colour, and often rough and dirty. They are so soft that they can usually be squeezed flat between the finger and thumb, becoming ductile and sticky. They break easily with a granular, irregular fracture, and are opaque, yellowish, and soft internally. Sometimes the tears are more or less translucent and of a bluish-green colour.

Galbanum occurs also in *lumps*, which consist of yellowish or bluish-green or brownish tears embedded in a brownish mass and mixed with slices of root and various foreign substances.

Thin transverse slices of the root are commonly found mixed with commercial galbanum; they are usually about 2 or 3 cm. in diameter and frequently bear on one side the dried secretion derived from the freshly cut surface. Winged mericarps of the fruits are also frequently present.

The drug has a characteristic, not exactly unpleasant, aromatic odour, and a rather disagreeable, aromatic, and bitter taste. An alcoholic tincture poured into alcoholic solution of ammonia yields a brilliant blue fluorescence, indicating the presence of free umbelliferone.

Constituents. Galbanum consists, apart from extraneous substances, of volatile oil (about 5 to 10 per cent.), resin (about 60 per cent.) and gum (about 20 per cent.), the residue being made up of inorganic matter (about 2 per cent., sometimes much more) and moisture (from 1 to 10 per cent.).

The resin, boiled with solution of potassium hydroxide, yielded galbaresinotannol and umbellic (dioxycinnamic) acid; the latter, however, is not contained in the drug itself, but is formed from umbelliferone, the anhydride of umbellic acid, which is first split off from the resin and then converted into umbellic acid. The galbaresinotannol was obtained as a brown powder; probably it is not contained in the drug but formed from other constituents by the action of the potassium hydroxide.

Good qualities of the drug should yield about 40 per cent. of substances insoluble in alcohol, about 10 per cent. of moisture, and give on incineration not more than about 7 per cent. of ash.

Uses. Galbanum is used chiefly as a stimulant in plasters.

ASAFETIDA

Sources. Asafetida is an oleo-gum-resin obtained from the root of *Ferula fœtida* Regel, *F. rubricaulis* Boissier, family Umbelliferæ, and probably other species. These are large umbelliferous plants growing in eastern Persia and western Afghanistan.

Collection. In the cortex of the stem, and also in the root, there are numerous large, schizogenous ducts filled with a whitish, gum-resinous emulsion.

The plant is a large herbaceous, monœcious perennial which develops a massive root. After about five years, when the root has stored sufficient reserves and is about 12 to 15 cm. thick at the crown, it throws up a large flowering stem about 10 cm. thick and 2·5 to 3 metres high. About the end of March, just before the plant is about to flower, the upper part of the

root is laid bare and the stem is cut off close to the crown. The exudation flows from the cut surface and, while it is hardening, is protected by a dome-like covering of sticks and leaves. A few weeks later the hardened gum-resin is scraped off, a slice of the root cut off, and the juice again allowed to exude, this process being repeated several times with intervals of about ten days.

Herat and Kandahar are the centres of the asafetida trade. The drug is exported from Bunder Abbas and other ports on the Persian Gulf,

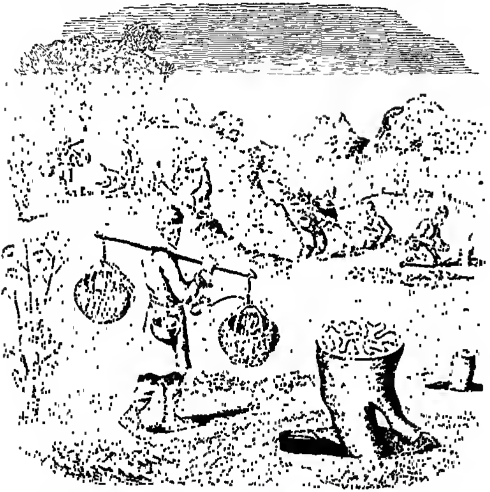

FIG. 194 Preparation and collection of Asafetida, from "Amœnitatum exoticarum," by E. Kaempfer, 1712. This old wood-cut still correctly illustrates all the essential details of the collection of Asafetida.

partly also from Bombay, mostly in large tin-lined cases, but a small quantity arrives as a pasty mass in tins or hides.

Description. Asafetida occurs in three forms, viz.: paste, tear and mass (block or lump). Paste and tear are the purer forms, but the bulk of the drug is mass.

The *tears*, some of which are separate, some more or less agglutinated together, are rounded or flattened, and vary from 0·5 to 4 cm. in diameter. They are ... colour; some darken on keep... ...it others retain their original ... ariety is

derived from *F. fœtida*, the white from *F. rubricaulis* (Small, 1913). When fresh they are usually tough at ordinary temperatures, becoming harder when cooled and softer when warmed. Internally they may be yellowish or milky-white, translucent or opaque; the freshly exposed surface may gradually pass through a very characteristic change of colour, becoming first pink, then red, and finally reddish-brown (*F. fœtida*), or may remain nearly white (*F. rubricaulis*). The drug has an intense, penetrating, persistent, alliaceous odour, and a bitter, acrid, alliaceous taste.

Mass asafetida consists of the tears agglutinated into a more or

FIG 195. Show of asafetida at London Dock. (Greenish).

less uniform mass and mixed with varying quantities of extraneous substances such as stones, slices of the root, earthy matter, calcium carbonate, calcium sulphate, etc.; it is generally much inferior to the tears.

Constituents. Asafetida consists principally of volatile oil, resin, and gum.

Good samples yield from 10 to 17 per cent. of volatile oil, from 40 to 64 per cent. of resin, about 25 per cent. of gum, and 1·5 to 10 per cent. of ash. The amount of mineral matter in mass asafetida may rise to 60 per cent., or exceptionally even more; fine tears may contain as little as 1·5 per cent.

Investigations by Baumann (1929) have shown that about 50 per cent. of the resin consists of resene and volatile oil. Part of the resene,

asaresene A, was obtained crystalline. The drug also contains about 1·3 per cent. of free ferulic acid and about 16 per cent. of a very unstable ester of ferulic acid with asaresinol. The latter is of phenolic nature, and is rapidly coloured red and subsequently brown on exposure to air and light, and is the source of the red coloration of the drug.

The volatile oil contains pinene together with various disulphides, $C_7H_{14}S_2$, $C_{11}H_{20}S_2$, $C_{10}H_{16}S_2$, etc., the percentage of sulphur varying from 17 to 38.

Although asafetida contains no free umbelliferone, a fact which distinguishes it from galbanum, it easily yields umbelliferone when boiled with hydrochloric acid which acts upon the ferulic acid and resorcinol produced simultaneously from the resin. This reaction also distinguishes the drug from a spurious variety met with in Bombay.

From galbanum the tears of asafetida may also be distinguished by the green colour the freshly fractured surface assumes when it is touched with nitric acid diluted with an equal volume of water, or by the bright red or brownish-red colour with sulphuric acid, changing to violet when the acid is washed off with water.

Uses. Asafetida is a powerful nervine stimulant, and is used in the nervous disorders of hysteria. It has also a well-marked stimulant action on the bowel, and is employed to expel flatulence and relieve constipation. Much of it is exported to the Continent and also to the United States, where it is used on the cattle ranches.

OLEO-RESINS

The drugs that are grouped together under the above heading are mixtures of resins with volatile oils or oily liquids. They are secreted in schizogenous or schizolysigenous ducts which may be of either normal (Canada turpentine, copaiba) or pathological (balsam of Peru, storax) origin.

All of the constituents may vary considerably in their composition. Those oleo-resins which contain benzoic or cinnamic acid are frequently termed "balsams"

CANADA TURPENTINE. Canada Balsam, Terebinthina Canadensis

Sources. Canada turpentine is an oleo-resin obtained by incision from

has long been known, is collected in Lower Canada, especially in the province of Quebec.

Collection. The tree contains schizogenous oleo-resin ducts, which are restricted to the bark, none occurring normally in the wood. In addition, however, to these secretion ducts, cavities are formed which fill with oleo-resin and produce blisters on the smooth trunk of the tree. From these blisters the oleo-resin is obtained by puncturing them with the pointed spout of a can which serves to receive the turpentine.

Description. Canada turpentine is a clear, transparent liquid about as viscid as honey, and of a pale yellow or greenish-yellow colour, often exhibiting a slight greenish fluorescence. By keeping it becomes more *viscid*, and finally it gradually dries to a hard resin which remains

transparent and shows little disposition to crystallise, a quality that renders it particularly valuable for cementing optical lenses and as a medium in which to preserve microscopical preparations It has an agreeable balsamic odour and a rather bitter and acrid taste It is completely soluble in chloroform, benzene, xylene and ether, but only partially in alcohol.

Constituents. Canada turpentine consists approximately of 16 to 24 per cent. of volatile oil mixed with from 70 to 80 per cent. of resin.

The volatile oil consists chiefly of *l*-pinene.

Of the resin about 20 per cent. is composed of an indifferent resene, canado-resene, which is remarkable for its insolubility in alcohol. A further 20 per cent of the resin is amorphous canadinic acid The remaining 60 per cent. consists of two amorphous resin acids, α- and β-canadinolic acids, associated with 0 5 per cent of crystalline canadolic acid.

The bitter principle, which is insoluble in water, has not yet been isolated.

Uses. Canada turpentine is extensively used as a microscopic mountant. For this purpose the resin, obtained by heating the turpentine until the volatile oil is driven off, is dissolved in xylene, or some other suitable solvent. It is also used for cementing lenses.

COPAIBA. Copaiva, Balsam of Copaiba

Sources. Copaiba is an oleo-resin obtained from the trunk of *Copaifera Lansdorfii Desfontaines, family Leguminosæ*, and other species of *Copaifera*

The trees from which the oleo-resin is obtained are large trees indigenous to Brazil and the north of South America The drug, which was highly esteemed by the natives of Brazil, and had probably long been used by them as a medicine, was introduced into Europe about the beginning of the seventeenth century.

Collection. The oleo-resin is contained in anastomosing, schizogenous secretion ducts that form an extensive network in each zone of the secondary wood of both stem and root, extending throughout the entire length of the zone. These ducts are formed in the young wood and rapidly attain their normal diameter, which is often very considerable; at the level of the insertion of the branches a number of lateral ducts connect zone with zone. In addition to these schizogenous ducts lysigenous cavities also appear to be formed by the breaking down of the cell walls and their probable transformation into resinous or oleo-resinous substances.

The oleo-resin is collected by cutting in the trunk of the tree near the base a cavity sloping inwards and downwards, and penetrating to the centre of the trunk, resembling the "box" made in the trunk of the turpentine trees. Into this cavity the oleo-resin is discharged; it is transferred to barrels and other vessels for exportation.

The large size of the secretion ducts and lysigenous cavities, and their extensive distribution in each zone of wood throughout the entire length of the tree, render the amount of oleo-resin that may be secreted by each tree very considerable. Even as much as 48 litres are said to have been obtained from a single tree, others again yielding but little.

The drug is exported from the seaports on the northern coast of South America—viz. Para, Maranham, Maracaibo, Bahia, Cartagena, etc , these towns giving their names to the commercial varieties of the drug. As these differ in the percentage of volatile oil and of resin, and in the composition of the latter, the following typical commercial varieties may be described.

Maracaibo Copaiba

Description. Maracaibo copaiba is a clear, viscous, brownish-yellow fluid with a slight but distinct green fluorescence. It possesses a characteristic aromatic odour and an unpleasant, acrid and rather bitter taste. It is miscible in all proportions with chloroform, carbon disulphide, and benzene, and also with an equal volume of petroleum spirit, but with larger proportions of the latter a slight precipitation takes place; with absolute alcohol it behaves similarly. The specific gravity varies from 0·980 to 0·999, or even slightly higher. The proportion of volatile oil varies from about 35 to 50 per cent.

Constituents. Maracaibo copaiba consists of a mixture of resin and volatile oil with which traces of a bitter principle and fluorescent substance are associated.

The volatile oil is invariably lævorotatory, the rotation in 100 mm. tube varying from $-7°$ to $-35°$, usually, however, it does not exceed $-25°$; its specific gravity varies from 0·896 to 0·910 and its boiling-point from 250° to 275°; it does not respond to the test for gurjun balsam (see below).

The resin contains a small proportion of copaivic acid (removed by ammonium carbonate from ethereal solution), but consists chiefly of β-metacopaivic acid (extracted by sodium carbonate after removal of the copaivic acid); with these there is associated a small quantity of two indifferent copaibo-resenes and of crystalline illurinic acid (compare African copaiba).

The bitter principle and fluorescent substance have not yet been obtained in a pure state.

Uses. The active principles of copaiba are absorbed into the blood, the volatile oil, at least, being excreted by the kidneys, bronchi, and skin; hence copaiba produces along the whole genito-urinary tract, as well as in the bronchi, a stimulant and disinfectant action, increasing the mucous secretion and exciting expectoration. It is now chiefly employed in inflammatory affections of the bladder and urethra, and occasionally in chronic bronchitis. The resin is inert or nearly so.

Para Copaiba

Description. Para copaiba is a thin, clear, bright yellow liquid, quite free from any fluorescence. The specific gravity varies from 0·917 to 0·980, but is usually low. In accordance with the greater fluidity of this variety [illegible] t 55 to 90 per cent. In [illegible] variety.

[illegible] ally of volatile oil and resin. The resin consists of amorphous resin-acids associated with crystalline paracopaivic acid (2 per cent.), homoparacopaivic acid, and two resenes. The volatile oil appears to be identical with that of Maracaibo copaiba, but the resins are certainly not.

African Copaiba

African copaiba, the botanical source of which is not known, is imported from the Niger basin in West Africa. It is a rather dark yellow, slightly fluorescent oleo-resin possessing an aromatic, piperaceous odour and frequently depositing crystals on standing. The specific gravity varies

from 0·985 to 1·000. It contains … f volatile oil and 60 per cen …

Constitu … essentially from the oil of … American copaiba in being dextrorotatory, the rotation in 100 mm. tube being about 10° 21′.

The crystalline deposit consists of illurinic acid identical with that obtained from Maracaibo copaiba. The remainder of the resin consists of amorphous resin-acids, fluorescent substance, etc.

ADULTERANTS OF COPAIBA

The following are the chief adulterants and the means of detecting them.

Fixed …
tio …
or … copaiba) hard and brittle. Th … of fixed oil can also be detected by a high ester value; copaiba resin consists … in-acids and has a very low ester value … 100).

Volatile … off the …

… to 100). The … a dextrorotatory oil would indicate the presence of African copaiba.

Colophony … them …

… 15 c.c. of 95 per cent. … and cooled should not separate oily drops (of paraffin oil).

Gurjun balsam, an oleo-resin obtained by incision from the trunk of *Dipterocarpus turbinatus* Gaertner, family Dipterocarpaceæ, and other species, large trees indigenous to eastern India and Burma, is used both as a medicine and for technical purposes. It somewhat resembles copaiba in odour and taste, but is usually darker in colour and fluorescent. It contains from 40 to 80 per cent. of volatile oil together with … acid resins, and has therefore … Its presence in copaiba may … of 5 mils of glacial acetic ac … reddish … diss … und …

… with a more valuable t … to detect.

BALSAM OF TOLU. Balsamum Tolutanum

Sources. Balsam of Tolu is a balsam obtained by making incisions in the trunk of *Myroxylon Toluiferum* Humboldt, Bonpland, and Kunth, family Leguminosæ. The tree is a native of Colombia, and occurs plentifully in the forests near the river Magdalena and its tributary the Cauca, and also on the … balsam … the …

Collection. Schizogenous ducts are present in the cortex of the young twigs, but are thrown off as the tree gets older. There are no secretory structures in the bark of the trunk, but ducts are probably formed in the young wood after an injury. Balsam of Tolu is therefore a pathological product.

To obtain the balsam, a notch is cut in the bark so as to leave a V-shaped tongue of bark projecting downwards in the centre of the injury. A small gourd or similar vessel is attached by pushing its edge under the point of the V and serves to collect the transparent fluid which exudes from the wound. Many such incisions are made into the trunk and gourds attached. The liquid balsam is transferred from the gourds to skins and is carried to the coast where it is put into tins in readiness for shipment from the ports of Savanilla and Carthagena.

Description. Balsam of Tolu when freshly imported is a soft, tenacious, yellowish-brown, resinous mass, which takes the form of the vessel in which it is kept. By keeping, it gradually hardens to a brownish and, especially in cold weather, brittle and easily powdered mass which, however, readily softens when warmed. It has an agreeable, fragrant, though not powerful odour, and an acidulous balsamic taste, and adheres to the teeth when chewed. A small piece warmed and pressed into a thin film between two glass slides exhibits, when examined by the microscope, colourless crystals (of cinnamic acid) embedded in a transparent mass.

It is easily soluble in alcohol, acetone, and chloroform, but only partially soluble in carbon disulphide. The solution obtained by gently warming the balsam with carbon disulphide leaves when evaporated about 25 per cent. of crystalline residue consisting chiefly of cinnamic and benzoic acids. Cocking and Kettle (1918) found an average of about 36 per cent. of total balsamic acids, free and combined, of which about 8 per cent. was free benzoic and 12·8 free cinnamic acid, 7 per cent. combined benzoic, and 8 per cent. combined cinnamic acid.

Constituents. Tolu balsam contains about 7·5 per cent. of an oily liquid (consisting of benzyl benzoate with a little benzyl cinnamate), traces of vanillin, free aromatic acids, principally cinnamic, and resin. The resin, amounting to about 80 per cent. of the drug, yielded by saponification an alcohol (toluresinotannol), and cinnamic acid, associated with benzoic acid.

Distilled with water good, fresh balsam of Tolu yields from 1·5 to 3·0 per cent. of a very fragrant volatile oil containing toluene, styrol, and free benzoic and cinnamic acids; it should yield not more than 4 per cent. insoluble in alcohol, 90 per cent.

Uses. Tolu balsam is used chiefly as a pleasant ingredient in cough mixtures It possesses antiseptic properties due to the cinnamic and benzoic acids contained in it.

Adulterants. The chief adulterants of balsam of Tolu are colophony and balsam that has previously been used in making syrup of Tolu and

Colophony may be detected by exhausting the balsam with carbon disulphide and evaporating the filtered solution. Pure balsam gives about 25 per cent. of crystalline residue; if colophony is present the residue is

resinous and gives with concentrated sulphuric acid a green colour; a petroleum spirit extract of the residue shaken with an equal volume of a 0·1 per cent. solution of cupric acetate assumes a bright green colour if colophony is present.

Exhausted balsam may be detected by the deficient amount of substances soluble in carbon disulphide and of balsamic acids.

BALSAM OF PERU. Balsamum Peruvianum

Sources. Balsam of Peru is a balsam exuded from the trunk of *Myroxylon Pereiræ* (Royle) Klotsch, family Leguminosæ, after the bark has been beaten and scorched.

The tree grows in the forests of that part of San Salvador (Central America), near the Pacific Ocean, known as the Balsam Coast, and probably also in other parts of Central America, as, for instance, in Honduras (Dieterich), the drug having received the name "Peruvian" from the fact that it was originally sent from San Salvador to Callao, the port of Lima, and thence to Spain

Collection. Ducts are present in the bark of the young twigs, but these are thrown off quite early and the trunk of the tree contains no ducts at all, so that the balsam is a pathological product. The bark of the trunk is beaten with a club or the handle of an axe or a stone over an area of about 30 × 15 cm. so as to remove the corky layer and wound the inner tissues. As a result ducts are formed and, after about five days, a secretion of balsam takes place and is soaked up by rags which are pushed under pieces of the bark raised by making incisions and lifting them up After about a week the wounded area is scorched by torches and a few days later an abundant flow of balsam takes place and is absorbed by the rags. The exhausted bark is finally removed and the exposed young wood is similarly treated, the flow ceasing in about six weeks from the start. Fresh areas of bark, higher up on the tree, are then beaten and scorched. The collected rags are put into strong rope bags and pressed by twisting the ends of the bags, the balsam being allowed to fall into hot water, where it sinks to the bottom; the water and impurities which float are then decanted.

The bark eventually removed is also boiled with water and the balsam so separated is mixed with the main exudation. The product is filled into tin canisters with screw openings, holding about 27 kilos each, and is conveyed on mules to Acajutla and Belize, whence it is exported chiefly to New York and Hamburg.

Description. Balsam of Peru is a rather viscid, oily liquid, resembling in appearance common black treacle; it appears black in bulk, but in thin layers it is dark reddish-brown and transparent. It has a fragrant, balsamic odour, and although it has no marked taste it causes, when swallowed, a burning sensation in the throat.

Balsam of Peru is heavier than water, its specific gravity varying within narrow limits—viz. from 1·137 to 1·158, being usually between 1·140 and 1·158, and this forms a valuable means by which adulteration can be detected, for many liquids that might be used for that purpose are lighter than water, and would appreciably depress the gravity. It is soluble in chloroform, and also in an equal volume of 90 per cent. alcohol, but with a larger proportion of the latter the mixture becomes turbid. It is practically insoluble in water, which removes from it a little cinnamic acid. It is completely soluble in solution of chloral hydrate (60 per cent. w/w.).

Its physical characters are so well marked, especially the odour and taste, that the drug is easy to recognise, but the detection of adulteration, especially with inferior qualities of the drug, which appears to be more or less regularly practised, is a more difficult problem.

Constituents. Balsam of Peru consists essentially of an oily fluid portion mixed with a dark resin. The fluid portion (cinnamein) constitutes from 56 to 96 per cent. of the drug, and consists of benzyl benzoate and benzyl cinnamate in the proportion of about three of the former to two of the latter, although this varies. Both esters are colourless, crystalline aromatic bodies which readily liquefy on heating. The resinous portion, amounting to about 28 per cent., appears to consist of esters of cinnamic and benzoic acids, but of the nature of the alcohol with which these are combined nothing definite is known. The drug also contains an alcohol, peruviol (= nerolidol), which has a sweet odour and taste, traces of vanillin, and free cinnamic acid.

Uses. Balsam of Peru is used internally as an antiseptic and expectorant; applied externally, it acts as an antiseptic and parasiticide, especially in scabies. It is used in the preparation of Tullo Gras.

Adulterants. Balsam of Peru is, from its nature and high price, liable to adulteration, chiefly with such liquids as alcohol, fixed oils, turpentine, copaiba, gurjun balsam, and the like. Any such admixture lowers the specific gravity, and can generally be detected by this means. Alcohol can be removed from the balsam by shaking it with water, which with the genuine drug should cause no appreciable diminution in volume. The presence of copaiba and of gurjun balsam can be detected by taking advantage of the insolubility of the resin of balsam of Peru in carbon disulphide. One part of carbon disulphide makes a clear mixture with 3 parts of balsam of Peru, but on the further addition of 9 parts of carbon

non-fluorescent
wn oil, and this
balsam of Peru,

e.g., of benzaldehyde or of turpentine. Dimethylphthalate may be detected by heating 1 drop of the balsam with 0·1 of resorcin and 10 drops of

en fluorescein is formed,
xed oils are detected by

de by mixing synthetic
th storax, benzoin, and
from that of genuine

balsam.

STORAX

Sources. Storax is a balsam obtained from the trunk of *Liquidambar orientalis* Miller, family Hamamelidaceæ, a tree of medium size forming forests in the south-west of Asiatic Turkey.

Collection. Neither the bark nor the wood of the tree possesses the agreeable odour of storax, and under normal conditions this substance is not produced in any part of the plant. In the early summer, incisions are made or the bark is beaten, but not so vigorously as to kill it; a formation of storax takes place, and the balsam soaks into the wounded bark, which is stripped off in the autumn. From the bark thus saturated the balsam

is obtained by pressing it, the residue being subsequently mixed with boiling water (or boiled with water) and again pressed. The liquid balsam thus obtained forms the storax of commerce, whilst the pressed bark was formerly an article of commerce, under the name of Cortex Thymiamatis. The latter, coarsely ground and mixed with storax, was formerly known as "Styrax calamitus."

Although the bark of the tree contains secretion ducts these do not take part in the production of storax, which is secreted in schizogenous ducts in the young wood; these, by the breaking down of intervening tissue, form schizolysigenous cavities from which the balsam exudes into the wounded bark. The secretion is therefore purely pathological: it is produced in the young wood, subsequently finding its way into the bark, with which it is removed when the latter is stripped off.

Description. Crude storax is a greyish, semi-fluid, viscid substance with an agreeable, aromatic, balsamic odour and a sharp, pungent taste. It is rather heavier than water, and contains usually vegetable débris, amongst which numerous sclerenchymatous fibres may be found. By drying it loses about 15 to 26 per cent. of water.

The crude drug is purified by dissolving it in three or four times its volume of hot alcohol, filtering, and removing the alcohol by gentle evaporation, care being taken to lose as little of the volatile constituents as possible. From 13 to 18 per cent. of the crude storax is insoluble in alcohol, the residue consisting principally of vegetable débris associated with inorganic matter. According to Evers (1896) storax contains from 6 to 9 per cent. of a greyish substance insoluble in alcohol, probably a resin ester of cinnamic acid.

Purified storax (*Styrax*) is a semi-transparent, yellowish-brown, semi-liquid balsam, entirely soluble in alcohol, ether, chloroform, and carbon disulphide. It should contain not less than 30 per cent. of total balsamic acids.

Constituents. Purified storax consists of a resin mixed with an oily liquid.

The resin is composed of storesinol, partly free, partly combined with cinnamic acid. Storesinol is a white, odourless, amorphous substance which, however, forms a crystalline potassium compound.

The oily liquid contains styrol (phenylethylene, a colourless, aromatic liquid), ethyl cinnamate, phenylpropyl cinnamate (odourless liquid), cinnamyl cinnamate (= styracin, odourless crystals), vanillin, and free cinnamic acid.

The approximate composition of storax, which, however, varies considerably, may be seen from the following table:

Free cinnamic acid	17 to 23 per cent.
Esters of cinnamic acid	24 to 25 ,,
Water	14 to 21 ,,
Resin	36 ,,

Purified storax may contain as much as 47 per cent. of cinnamic acid (free and combined), and is, in this respect, one of the richest drugs known.

Uses. Storax is a local and remote stimulant and antiseptic, resembling in these respects balsam of Peru, benzoin, etc. It is now seldom used.

Substitutes and Adulterants. The quantitative composition of storax is so variable that its purity can with difficulty be ascertained.

The acid value should vary between 60 and 90 and the ester value between 100 and 140. It should contain not less than 20 per cent. of total cinnamic acid. Storax of good quality yields often from 25 to 30 per cent. of acid.

Much of the storax imported, especially from Trieste and Marseilles, since 1907 was very deficient in cinnamic acid, the percentage dropping to 2 or 3. Such balsam had apparently been deprived of some of its most valuable constituents (particularly cinnamyl alcohol and cinnamic acid), which were in demand for the perfumery trade.

American storax or sweet gum is a transparent, yellowish, viscous liquid obtained from *L. styraciflua* Linn. It has been found to contain cinnamein 22·86 per cent., resin esters 31·76 per cent., resin acids 2·11 per cent., free cinnamic acid 12·63 per cent., total cinnamic acid 28·02 per cent. It has been recommended as a substitute for the Turkish.

CHAPTER XVII

FIXED OILS, FATS AND WAXES

FIXED OILS AND FATS

Fixed oils and fats are substances of either vegetable or animal origin; those that are fluid are known as oils, those that are solid as fats. They are lighter than and insoluble in water, greasy to the feel, leave a permanent translucent stain on paper and do not volatilise on exposure to the air. They are freely soluble in ether, chloroform and light petroleum, but are usually insoluble in alcohol, an important exception being castor oil which dissolves in 3·5 volumes of alcohol, 90 per cent. Chemically oils and fats are esters of glycerol which is combined with organic acids of high molecular weight, such as oleic, stearic, linolic and ricinolic acids. These esters are easily saponified by aqueous solutions of caustic alkalies, yielding glycerol and salts of the acids with the alkalies, which are termed soaps.

OLIVE OIL. Oleum Olivæ

Source, etc. Olive oil is the oil expressed from the pericarp of the ripe fruit of the olive tree, *Olea europæa* Linn., family Oleaceæ.

The olive tree is a small tree widely distributed by cultivation, especially in the countries bordering on the Mediterranean; it has been introduced into America and is cultivated in California, where large quantities of olive oil are now produced. It is also cultivated in southern Australia.

Preparation. The fruit of the olive is a drupe, about 2 to 3 cm. long, green while unripe, in which condition it is pickled for use as a table relish. As the fruits ripen they change colour from green to purple and the mesocarp becomes filled with oil. The fruits are collected in the winter and spring—December to April—usually by shaking and beating the trees, when the olives fall off on to sheets placed on the ground to receive them; some are collected by ladders. The ripe fruits are sorted out and are crushed in an edge-runner mill, having stones sufficiently heavy to crush the pulp, but not to break the endocarp or stone of the fruit. The crushed fruits are put into coarse circular bags about 60 cm. in diameter and tied up; the bags are piled one upon another and subjected to a moderate pressure, using in the more remote districts a wooden screw hand-press and in the larger factories a steel screw press operated mechanically. The crude oil is run into tubs and mixed with water, which removes colouring matter and other impurities, and is allowed to stand till the oil separates, when it is skimmed off and filtered. This yields the first quality oil, known as "virgin oil," which is the variety suitable for medicinal use. The marc from this operation is ground up, mixed with hot water and again pressed, this time more strongly, and yields a second quality of oil.

The residue still contains a little oil which may be obtained by a third pressing or by extraction with solvents; such oil is usually used for soap-making, etc. Sometimes all the fruits are thrown into heaps and allowed to ferment; on pressing, the whole of the oil is obtained, but it is of inferior quality, and is used principally for technical purposes.

Description. Medicinal olive oil—virgin oil—has a pale yellow or greenish-yellow colour, a slight characteristic odour, and a bland taste without rancidity. Its specific gravity varies from 0·915 to 0·918. It is liquid at ordinary temperatures, but when cooled to 10° it assumes a pasty consistence, from deposition of solid fats, and at 0° it becomes a nearly solid, granular mass.

Constituents. Olive oil consists chiefly of olein and a little palmitin, together with linolein and traces of arachin, the palmitin and arachin separating out in the solid form when the oil is cooled. By saponification these compounds yield respectively oleic, palmitic, linolic, and arachic (or arachidic) acids together with glycerol.

Uses. Olive oil has nutritive and laxative properties. Applied externally it is emollient and soothing.

Substitutes and Adulterants. Valuable indications of purity of olive oil are to be found in the specific gravity (0·915 to 0·918), the iodine value (79 to 87), and refractive index (1·4605 to 1·4635 at 40°). The free acid present should not exceed 1 per cent., calculated as oleic acid; lower qualities may contain up to 5 per cent. of acid, and oils for technical purposes as much as 30 per cent.

Cotton-seed oil, a frequent adulterant, is best detected by Halphen's (Bevan's) test, which consists in warming 2 mils of the oil mixed with 1 mil of amylic alcohol and 1 mil of a 1 per cent. solution of sulphur in carbon disulphide for ten minutes in a water-bath, when no red colour should be developed (but this test fails to detect cotton-seed oil that has been heated to over 200°).

Sesamé oil is tested for by mixing 2 mils with 1 mil of hydrochloric acid containing 1 per cent. of sucrose, shaking for half a minute, when the

[illegible] arating the fatty [illegible] ch should not be [illegible] 77° C., which is [illegible]

CASTOR OIL. Oleum Ricini

Source. The oil expressed from the seeds of *Ricinus communis* Linn., family Euphorbiaceæ. See p. 188.

Preparation. In some factories the oil is expressed from the entire seeds, but in others the testas are first removed. For this purpose the seeds are sorted according to size and then cracked between spaced and grooved rollers, the testas being fanned away by a current of air. The kernels are then fed into the oil-press and are subjected at ordinary temperature to a pressure of 1 to 2 tons per sq. in. until the weight of the expressed oil is about 30 per cent. of the weight of the seeds. The oil is filtered, steamed to about 80° to 100° to coagulate proteins and again filtered. The steaming is done to remove the small amounts of ricin and of lipase which the oil contains; the ricin is toxic and the lipase would hydrolyse the oil and render it rancid (see p. 189). This operation yields "[illegible] about 1 per cent. [illegible] which also contains ab[illegible] ound and heated by steam to about 40° to 80° and are pressed at about 3 tons per sq. in., when they yield a second quality oil, which is used for technical purposes and has an acidity of about 5 per cent. The cakes still contain about

8 to 10 per cent. of oil which can be extracted by benzene or carbon disulphide. The cakes are useless for feeding cattle and are used as a manure and as a source of lipase, which is used commercially for splitting

of accurately fitting hard-steel bars (about 4 or 5 ft. long) placed vertically side by side and held in position by steel hoops. The rods are recessed so as to form fine vertical channels (about $\frac{1}{150}$ in. wide) between them; this allows the oil to escape to the outside of the cylinder, while the tissues of the seeds are retained. The oil flows down the outside of the "cage" and collects in a circular trough at the base. The head of the hydraulic ram carries a thick steel plate which accurately fits the inside of the "cage" and, to fill the press, the ram is raised until its head is about 6 in. below the upper end of the cage and seeds are introduced to fill the remaining space; they are covered by a cloth and a steel plate and then another cloth. The ram is now lowered about 6 in. and another charge of seeds is put in position and so on until the press is filled. The head of the press is then placed in position above the cage, when the ram is again forced upwards and the oil is expressed. After the expression, the head of the press is swung to one side and the cakes are forced out of the top of the cage by raising the ram.

us, slight odour, acrid unpleasant ta iodine value 82 to 90, saponifi- ca not over 4; refractive index 1·4695 to 1·4730 at 40°; solidifying point —10° to —18°; acetyl value about 150; soluble in all proportions in absolute alcohol and in 3·5 parts of alcohol (90 per cent.).

Constituents. Castor oil consists of the glycerides of ricinoleic, isoricinoleic, stearic and dihydroxy-stearic acids. Its freedom from admixture with other fixed oils is shown by the petroleum spirit test: to 60°) form a clear petroleum spirit the

Uses. A mild purgative; on account of its viscosity it is largely used, especially in warm climates, as a lubricant.

Note. Turkey red oil is obtained by allowing sulphuric acid to run

COD-LIVER OIL. Oleum Morrhuæ

Sources. Cod-liver oil is the oil extracted from the fresh liver of the cod, *Gadus morrhüa* Linn., family Gadidæ, order Teleostei.

Preparation. The cod inhabits the North Atlantic Ocean in great numbers, finding its food on the ocean floor. At spawning time, *i.e.*, from January to April, it migrates to the seas around the Lofoten Islands, off the northern coast of Norway, and to the coasts of Newfoundland. Here the cod feeds chiefly on young herring which themselves feed upon the plankton living in the brilliantly sunlit upper zone of the sea where vitamin D is formed chiefly by the activity of the diatoms The animal

organisms of the plankton live largely on the diatoms and the herring thus obtain supplies of vitamin D which is in turn transferred to the cod which conserves it in the fat of the liver. The fishing fleets consist of motor-trawlers, or sailing-boats or rowing-boats and they use both lines and nets to catch the fish. The fishing grounds are often about six miles from the shore and on the return journey the fishermen remove the livers from the fish and separate the gall-bladder. At the factory on shore, the livers are washed, cut into slices and heated in large vats to a temperature of 82° by admitting steam. The liver of the cod weighs about 4 kilos and contains from 30 to 65 per cent. of oil and also lipases. A temperature of at least 70° is required to destroy the lipases and the heating operation takes about thirty minutes, the oil beginning to separate at about 55°. The oil is removed with a dipper and is put into large tin drums, which are encased in wooden barrels. The barrels are buried in the snow and the oil cooled to − 2° or − 5°; the slow cooling caused by the air-space between the barrel and the tin causes the solid fat, chiefly palmatin, to separate in a granular form, which is more easily removed by filtration. The oil thus obtained is the non-freezing, medicinal oil of commerce.

From the liver residues more oil is obtained by heating to a higher temperature or by a process of heaping and partial decomposition; such oils are brownish and of inferior quality.

Description. Cod-liver oil has pale yellow colour, and a slightly fishy, but not rancid odour. Its specific gravity varies from 0·922 to 0·929; it is readily soluble in ether and chloroform, but sparingly in alcohol. It remains clear when cooled to 0° and maintained at that temperature for three hours. The oil has a high iodine value of 155 to 173.

Constituents. Cod-liver oil consists chiefly of glycerides of unsaturated acids, about 85 per cent., the chief of which is decosohexaenoic acid (Tsujimoto (1906, etc.) has isolated, as the chief unsaturated acid in Japanese cod-liver oil, clupanodonic acid); also a small amount of glycerides of saturated acids, including palmitic and stearic acids and from 0·5 to 1·0 per cent of unsaponifiable matter, including cholesterol, batyl alcohol, squalene (a hydrocarbon) and the vitamins A and D. One gramme of cod-liver oil contains about 1,000 to 35,000 international units of vitamin A and 60 to 150 international units of vitamin D.

Storage. Cod-liver oil must be protected from oxidation and from the action of light, both of which lead to the destruction of the vitamins, especially vitamin A. Oxygen of the air oxidises the unsaturated acids, breaking them down into acids of lower molecular weight and producing both rancidity and resinification; the acidity helps to destroy vitamin A. Cod-liver oil must therefore be stored in well-filled and well-closed containers and, for small quantities, amber-glass bottles are commonly used.

Uses. Cod-liver oil is employed as a nutritive and is particularly valuable in rickets.

Adulterants. Cod-liver oil is liable to adulteration with other fish-liver oils and with seal oil, the detection of which is exceedingly difficult.

Note. Whale oil (*Balæna* sp.), seal oil (*Phoca* sp.), dolphin oil (*Delphinus* sp.), and shark oil (*Carcharias* sp.) are used as illuminants, lubricants, for leather-dressing and soap-making. Large quantities of whale oil are

converted by hydrogenation into bland edible fats of varying degrees of hardness.

HALIBUT-LIVER OIL. Oleum Hypoglossi

Sources. Halibut-liver oil is obtained from the liver of the halibut, *Hippoglossus hippoglossus* Linn., family Pleuronectidæ, the largest species of the group of flat-fishes. It inhabits the North Atlantic Ocean and the North Sea.

The oil is removed from the dried livers by extraction with a volatile solvent, which is later removed at a low temperature. The oil is pale yellow and has a fishy odour and taste. The unsaponifiable fraction of the oil amounts to about 8 to 10 per cent. of the oil and halibut oil contains 60 to 100 times as much vitamin A as cod-liver oil and about 20 times as much vitamin D.

SUET. Sevum

Sources. Medicinal suet is purified mutton suet, obtained from the abdomen of the sheep, *Ovis aries* Linn., family Bovidæ, order Ungulata.

Preparation. It is the fat contained in the vesicles of the omentum or folds of the peritoneum and about the kidneys that is used for making suet. The fat is purified by thoroughly crushing the omentum, etc., so as to break the membranous vesicles in which the fat is contained, melting, and straining through linen or flannel. During the cooling it should be stirred, so as to prevent the constituents of higher melting-point separating in a more or less granular form.

Description. Suet is a white, smooth, uniform, firm and unctuous fat, it possesses a slight characteristic odour, and is free from rancidity. When exposed to the air, it becomes rancid after a long period. It melts at about 45° to 49°, and has a specific gravity of 0·948 to 0·953 (at 15°). Suet is soluble in ether, chloroform and light petroleum.

Constituents. It consists principally of stearin and palmitin (about 70 to 80 per cent.), associated with olein (about 20 to 30 per cent.). The acid value should not exceed 2; saponification value 192 to 195; iodine value 33 to 46; refractive index at 60° 1·4490 to 1·4510; melting-point 45° to 50°.

LARD. Adeps

Sources. Lard is the purified fat from the abdomen of the hog, *Sus scrofa* Linn., family Suidæ, order Ungulata.

Preparation. The abdominal fat of the hog is obtained in the form of flat, leafy masses known as "flare," which consists of the omentum and other portions of the peritoneum. These should be first washed to free them from any salt that may have been used to preserve them, then stripped as far as possible of external membrane, and hung in a current of air for a few hours to dry. They must then be crushed or comminuted in any suitable manner, such as by beating in a stone mortar or passing through a mincing machine, in order to break the membranous vesicles and liberate the fat contained in them. The crushed fat is exposed to a temperature which should not exceed 57° (in order to avoid the injurious effect of too great heat), and when completely melted strained through fine muslin and gently stirred till cool, avoiding any form of beating which would introduce air into the melted fat and favour the development of

rancidity. If not stirred t' ...
from the crystallisation of
and palmitin). This proce

Description. Lard is a soft, white, homogeneous, fatty substance melting at about 34° to 41° and having at 15° a specific gravity of about 0·934 to 0·938. Odour slight, fatty, but not rancid or otherwise disagreeable; entirely soluble in ether, chloroform and light petroleum. Acid value not over 1·2; saponification value 192 to 198; iodine value 52 to 56; unsaponifiable matter not over 0·5 per cent.; refractive index at 60° 1·4520 to 1·4550.

Constituents. Lard consists of about 40 per cent. of stearin and palmitin mixed with about 60 per cent. of olein, but these proportions are subject to a little variation, and with them both melting-point and specific gravity. The olein, separated by pressure at about 0°, is known in commerce as lard oil.

Adulterants. Lard is liable to contain common salt, which is often added to preserve it for domestic use; it may be tested for chlorides by boiling with water, cooling, filtering the aqueous liquid, and adding silver nitrate and nitric acid. Starch, which might be added to give it a whiter appearance, could also be detected in the filtrate by solution of iodine. Sesamé oil may be detected by the test detailed under "Olive Oil" (p. 446). The most frequent adulterant of lard is cotton-seed oil, which has been found in American lard, large quantities of which are imported. It may be detected by the tests described under "Olive Oil" and by a rise in the iodine number which should not exceed 60. It should be noted that lard obtained from hogs fed upon cotton cake may give a positive result with Halphen's test.

WAXES

Waxes are solid, or occasionally liquid substances, somewhat resembling fats and oils in their physical characters, but differing in chemical composition. They consist of mixtures of esters or of esters and acids, but never contain esters of glycerol. The esters present are combinations of the higher fatty acids with monohydric alcohols of high molecular weight, such as ceryl and myricyl alcohols, cholesterols and phytosterols. Waxes are distinguished by the fact that they require treatment with alcoholic caustic alkali for their saponification whereas fats and oil are saponifiable by aqueous solutions of alkalies.

BEESWAX. Cera flava, Cera alba

Sources. Beeswax is the wax separated from the honeycomb of the hive bee, *Apis mellifica* Linn., and possibly other species of *Apis*, family Apidæ, order Hymenoptera.

Wax is imported from Jamaica, California, Chili, Egypt, Syria, Madagascar, Morocco, etc.

is exuded through minute pores in the chitinous areas. The little scales or plates of wax become solid and project between the overlapping sterna. These scales of wax are removed by the pincers on the hind legs between the tibia and the planta of the tarsus, the scale being pierced and firmly held by the comb-like fringe of the tibia. They are passed forward to the front legs and finally to the mouth where they are masticated by the mandibles with the addition of saliva which renders the wax more tenacious and workable. It is then built into the comb.

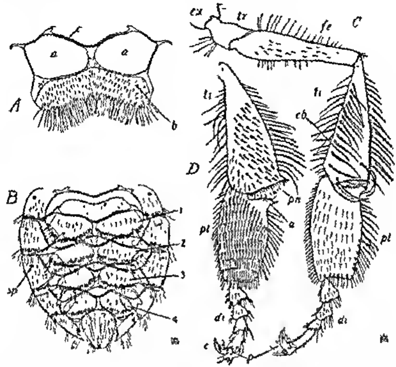

Fig. 196. *Apis mellifica*, the worker bee. *A*, ventral plate of a worker bee. *B*, lower surface of the abdomen of a worker bee. *a*, transparent area upon which wax is secreted, *b*, portion of the plate carrying hairs and overlapping the plate immediately posterior to it, *c*, chitinous frame, *sp*, spiracle, 1, 2, 3 and 4, the four overlapping ventral plates upon which wax is secreted. All × 6

C and *D*, hind legs of a worker bee. *C*, outer surface of a leg. *D*, inner surface of the tibia and tarsus of a leg. *a*, auricle, *c*, claw, *cb*, corbiculum or pollen basket, *cx*, coxa, *di*, digiti or small joints of the tarsus or foot, *fe*, femur, *p*, pulvillus or cushion between the claws, *pl*, planta or first joint of the foot, *pn*, pecten or comb, *ti*, tibia, *tr*, trochanter. All × 15.

After removal of the honey (p 412) the cappings or the extracted comb and cappings are melted in boiling water and, when cold, the wax forms a cake on the surface. This is removed and purified from suspended matter by melting in a deep vessel and allowing it to stand in a fluid state for some time, during which suspended impurities sink. The pure wax is poured off into earthen vessels previously wiped with a wet cloth. If the entire comb is to be used in this way for making wax, the foundations should be made of pure beeswax, otherwise the cappings only should be used.

White wax is made by melting the yellow wax and running it in a thin

stream on to a revolving wet drum, from which a scraper removes it in the form of long ribbon-like strips. These strips are laid on flannel to bleach in the sun. The process is repeated by remelting and exposing a second or third time to sunlight. White wax is also made by bleaching with chemicals, such as chromic acid.

Description. Yellow wax is a yellowish or brownish-yellow solid, with an agreeable, honey-like odour, breaking with a granular fracture, and not unctuous to the touch. It is readily and entirely soluble in hot oil of turpentine, partially and sparingly soluble in alcohol, soluble in warm ether, chloroform and in volatile and fixed oils generally. It is practically insoluble in water and in boiling aqueous solution of sodium hydroxide.

The specific gravity of wax varies from 0·958 to 0·970; melting-point from 62° to 64°; refractive index at 80° 1·4380 to 1·4420. These limits are narrow, and the specific gravity and melting-point often afford very valuable information as to the purity of the sample under examination. The ratio number, *i.e.*, ester value (70 to 89) divided by the acid value (17 to 23), is 3·3 to 4·0.

Constituents. Beeswax consists principally of melissyl palmitate (myricin) about 80 per cent., with which is associated free cerotic acid about 15 per cent., and small quantities of an aromatic body, cerolein, and probably melissyl stearate.

Adulterants. Beeswax is liable to adulteration with solid paraffin, ceresin, with various fats and waxes of vegetable or animal origin, with resin, stearic acid, etc.

Paraffin and ceresin (which is purified "ozokerite," a kind of paraffin) may be detected by the fact they are less soluble in alcohol than are the products of saponification of beeswax with caustic potash. One gramme of the wax is boiled under a reflux condenser with 10 ml. of semi-normal alcoholic caustic potash and 10 ml. of alcohol, 95 per cent. After an hour

tho flask is detached, a th r ia inserted and tho contents allowed
to cool with constant sti o x is genuine, the liquid becomes
cloudy between 61° and 5 of large flocks takes place at
not more than 2° bolow t hich the liquid first becomes
cloudy. A sample of wa 0 per cent. of hard paraffin,
treated way h becomes cloudy at about
65° and te

Res wo by cold alcohol, in which
genuin ar soluble.

Soap he fil would become
cloudy om tion of tho fat
acid).

Stea and all fats
easily s n of boiling
aqueo ably attack
wax; drochloric
acid.

Star tected by
boiling bstances,
such as ubility in
oil of t ax with

Forei ltering;
alcohol
the filt

Note. *Japan Wax* is the fat secreted in the mesocarp and cotyledons of the fruit of *Rhus succedanea* Linn., and other species of ... Anacardiaceæ, Japan. The ...
and boiled with water;
straining, and then pour ... pale yellow solid, becoming white externally on keeping; it consists chiefly of palmitic acid and its glyceride. Melting-point about 50° to 56°. It is not a true wax, but a fat.

Carnauba Wax is the wax secreted ...
Copernicia ...
dried
and
...

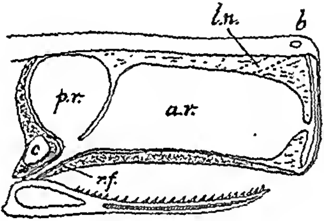

FIG. 197. *Physeter macrocephalus*. Se... whale. *a r.*, anterior reservoir and *p* ... right nostril; *b*, blow-hole; *c*, crania... nasal fossa (After Collin.)

chinensis Roxburgh ... stripped from the ... by re-melting, a ... crystalline, almost ... about 81° to 83°; consists almost en... cetotate

SPERMACETI. Cetaceum

Sources. Spermaceti is a solid wax obtained from the head of the sperm whale, *Physeter ma...* ... mily Physeteridæ, order Cetacea, ar... Part of the spermaceti of commer... bottle-nosed whale, *Hyperoodon rostratus*, Lilljeborg, family Ziphidæ.

The sperm whale inhabits ... Indian Oceans, ... it is also found ... Francisco.

C... and Preparation. Its head is of enormous size, occupying about one-third of the animal, which varies from 15 to 25 metres in length.

In a special, large, cylindrical organ in the upper region of the huge jaw and above the right nostril an oily liquid, crude sperm oil, is secreted. After the whale has been captured this cavity is emptied of its oil, which, on cooling, deposits a quantity of crystalline matter. This, the spermaceti, is separated by pressure and purified by re-melting, and washing with dilute solution of sodium hydroxide to free it from the last traces of oil; the spermaceti is washed with boiling water to separate it from the soap thus produced, and from excess of free alkali and, on cooling, it forms white crystalline masses.

Description. Spermaceti occurs in translucent, crystalline masses, pearly white in colour and unctuous to the touch; it has but little odour or taste. Specific gravity 0·95 to 0·96; melting-point 46° to 50°; acid value not more than 1; saponification value 125 to 136; iodine value 3 to 44; refractive index at 80° about 1·4330. It is insoluble in water and cold alcohol, but soluble in ether, chloroform and boiling alcohol, crystallising from the latter solvent on cooling.

Constituents. Spermaceti consists principally of cetyl palmitate, $C_{15}H_{31}\cdot COOC_{16}H_{33}$, together with a small proportion of esters of other fat acids.

Adulterants. Spermaceti has been adulterated with stearic acid, stearin, tallow, and paraffin wax. Stearic and other fat acids raise the acid value; stearin, tallow, and paraffin wax are insoluble in boiling alcohol; stearin and tallow raise the saponification value, but paraffin wax lowers it.

Note. *Ambergris* is a substance formed in the intestine of the whale, and found there or floating in the sea. It occurs in masses varying in size from 1 to 20 or more pounds, greyish in colour, veined, brittle, with an agreeable, persistent odour recalling musk. It contains 25 per cent. of ambrein which appears to be a derivative of cholesterol. The horny beaks of cuttle fish, upon which the sperm-whale feeds, are often found in ambergris and are regarded as an indication of genuineness.

WOOL FAT. Lanolin, Adeps Lanæ

Sources. Wool fat is a waxy substance secreted upon the hairs constituting the fleece of the sheep, *Ovis aries*, Linn., family Bovidæ, order Ungulata.

Preparation. If a few hairs of raw sheep's wool are examined under the microscope little masses of fatty substance may be seen adhering to them. This is the crude, natural, wool fat; part of it is soluble in water and is removed during the first cleansing process, which consists in steeping the fleeces in water; part is insoluble in water and can subsequently be removed by benzene, acetone, or other suitable solvent, forming, after evaporation, a brownish grease. It is also removed when the fleeces are scoured with soap and water, the second cleansing process. When the emulsion thus produced is acidified, the wool fat is separated together with the fat-acids produced by the decomposition of the soap. These fat-acids can be converted into the corresponding calcium salts and the wool fat separated by treating the product with acetone; the acetone solution, evaporated to dryness, yields crude wool fat which has to be purified by suitable means.

Wool fat may also be extracted by scouring the fleeces with hot water, and allowing the emulsion thus produced to stand, when impure wool fat rises as a cream. This can be cleansed by repeatedly mixing with water

and separating by centrifugation, the resulting wool fat being subjected to a final process of purification.

Description. Purified wool fat is a yellowish, tenacious, unctuous solid with a characteristic odour. It melts at about 34° to 40° and is soluble in acetone, benzene, and other fat solvents. The iodine value is 18 to 32. It may be distinguished from true fats by its solubility in absolute alcohol and also by the following test for cholesterol: Dissolve 0·5 gm. in 5 mils of chloroform, add 1 mil of acetic anhydride and 2 drops of sulphuric acid; a deep green colour is produced.

Constituents. Wool fat consists chiefly of cholesteryl and iso-cholesteryl alcohols combined with lanoceric, lanopalmitic, carnaubic, myristic, a little oleic, and possibly also palmitic and cerotic acids.

Uses. Wool fat is largely used as an emollient and for promoting the absorption of drugs by the skin.

Adulterants. The most probable adulterants of wool fat are mineral fats (soft paraffin) or animal and vegetable fats and oils. Wool fat, like most waxes, is not readily attacked by boiling, aqueous solution of potassium hydroxide, but may be saponified by boiling, or heating under pressure, with an alcoholic solution of the same, the saponification value varying from 90 to 102; it is also readily saponified by solution of sodium ethylate. Mineral fats are not attacked by either aqueous or alcoholic solution of potassium hydroxide, and their presence would lower the saponification value. Animal and vegetable fats and oils would by the same treatment be saponified and raise the saponification value; they would also be saponified by aqueous alkalies which would not attack wool fat or mineral fats. Glycerol can be detected by shaking the wool fat with hot water and evaporating the aqueous solution.

CHAPTER XVIII

GLANDS AND GLANDULAR SECRETIONS

THYROID GLAND. Thyroideum

Sources. Thyroid consists of the thyroid gland of the ox, *Bos taurus* Linn. or the sheep *Ovis aries* Linn., both belonging to the family Bovidæ, or the pig, *Sus scrofa* Linn., family Suidæ.

Description. The gland is composed of two flattened, ovoid lobes situated on either side of the upper part of the trachea or windpipe,

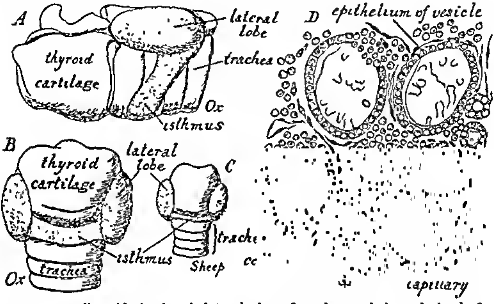

FIG. 198. Thyroid gland *A*, lateral view of trachea and thyroid gland of the ox, *Bos taurus*, × ½. *B*, thyroid gland and cartilage of the ox, seen from the front, × ½. *C*, thyroid gland of the sheep, *Ovis aries*. *D*, section of thyroid gland × 300.

just below the thyroid cartilage of the larynx and extending downwards over the upper two or three rings of the trachea. The lobes are connected across the front of the trachea by a band of glandular tissue named the isthmus. In the *ox* the lobes are bright red-brown and each is about 6 to 7·5 cm. long, 3 to 4 cm. wide, and 0·75 to 1·5 cm. thick; the isthmus is about 10 cm. long and 1·0 to 1·5 cm. wide, and passes across the front of the wide trachea between the lower ends of the lobes. Each lobe weighs about 10 to 15 gm. In the *sheep* the lobes are dull-red, each is about 3 to 4 cm. long, 1·25 to 1·5 cm. wide, and 0·5 to 0·75 cm. thick, and weighs about 2 to 3 gm. The isthmus is quite narrow, being about 3 to 5 mm. wide and 2 to 2·5 cm. long. In the *pig* the thyroid is dull-red, each lobe weighing about 6 to 12 gm., the two being connected by a wide isthmus.

The gland owes its colour to the abundant blood supply; it is covered externally by an envelope of fibrous connective tissue which penetrates the mass of the gland as a network of delicate laminæ

which surround ovoid or rounded masses, known as vesicles, within the gland. Internally, therefore, the gland is firm and coarsely granular; the secretion is present as a yellow glairy fluid filling the … carried through

… *nd.* The glands are separated and all connective tissue and fat is removed; they are then sliced and minced and are dried rapidly in a current of warm air …

fatty matter when cut, or are otherwise abnormal, are rejected. The dried thyroid so produced is a pale, buff-coloured, hygroscopic powder, having a faint meaty odour and taste. The powder is assayed and its strength adjusted to the required standard by mixing, if necessary, with lactose. It should be *stored* in a cool place, in well-closed containers.

Histology. The vesicles of the gland are ovoid or rounded cavities about 100µ in diameter; these are lined by an epithelium of a single layer of cubical or prismatic cells and are filled with a coagulable proteinaceous fluid. The laminated tissue between the vesicles is traversed by nerves and blood-vessels and communication between the vesicles is established by fine hyaline threads and cross tubes of irregular section. The vesicles …

the most characteristic feature is the large number of highly refractive vitreous fragments of the colloid, which have striated conchoidal surfaces and sharp angular edges. The powder is conveniently examined by soaking in dilute solution of ammonia, washing several times with water and staining with Löfflers blue.

Constituents. The active constituent, which is present in the colloid of the vesicles, is a crystalline principle, thyroxine, which has been prepared synthetically. It is insoluble in water and in alcohol, but soluble in acidified alcohol and in solution of sodium hydroxide, …

logically inactive.

Uses. Thyroid gland is used in myxœdema, goitre, obesity, and other cases in which a deficient production of the secretion is indicated. Small doses of thyroid are also prescribed as a general tonic.

PARATHYROID GLAND. Parathyroideum

Sources. The parathyroid glands are small, oval or spherical ductless glands, either embedded in the thyroid gland (internal parathyroids) or situated at some distance from it (external parathyroids). The parathyroids of the ox, *Bos taurus* Linn., family Bovidæ, are generally employed for medicinal use.

Description. In most thyroid glands there is normally one parathyroid embedded in the tissue near the upper and lower extremity of each lobe

of the thyroid, from which they can be distinguished by their distinctly paler colour. In some animals there is only one in each lobe; in the ox there are, in addition to the four typical parathyroids, several accessory parathyroids situated in various regions of the neck. For pharmaceutical use the external parathyroids of the ox are carefully dissected out. These parathyroids of the ox are flattened ovoid and measure about 17 mm. in length, 10 mm. in breadth and 4 mm. in thickness. They are freed from extraneous tissue and fat, desiccated and powdered.

Constituents. The active constituent is a hormone, named parathormone, but there is little information as to the chemical constitution of this substance.

Uses. It has been found that removal of the parathyroids results in a decrease in the quantity of calcium in the blood-serum and an increase in the quantity of guanidine and allied substances; hence the object of administering preparations of the parathyroids is to control the amount of these substances, especially in conditions of abnormal calcium metabolism, such as hay fever, asthma, chilblains, etc.

PITUITARY GLAND. Pituitarium

Source. Pituitary gland, also known as the hypophysis, lies in the median line at the base of the brain and is taken from various mammals, such as the ox, sheep and pig. That usually preferred is obtained from the ox, *Bos taurus* Linn.

To remove the gland, the crown of the skull is cut away, the brain is removed and the pituitary body is then taken from the depression in the sphenoid bone at the base of the skull, known as the *sella turcica*. It is immediately frozen and kept in that condition until required for use; it should be used within twenty-four hours.

Description. The gland is about 2 cm. in diameter and weighs from 2·5 to 3·0 gm.; it is separated from the base of the brain by a layer of tough fibrous tissue, connection with the brain being made at one point by the "stalk" or *infundibulum* of the gland, which passes through the fibrous covering. The gland consists of three parts, two of which, the posterior lobe and the anterior lobe, form the bulk of the gland and are separated by a narrow region named the *pars intermedia*. The posterior lobe has an average weight of about 0·5 g. and is derived from the brain with which both it and the *pars intermedia* are connected by the stalk. The posterior lobe is whitish-grey in colour and is composed of nerve tissue, viz., neuroglia cells, fibres and pituicytes. The anterior lobe has an average weight of about 2 gm., it is greyish-red and is derived from the tissue of the roof of the mouth, from which it eventually becomes entirely separated; it is composed of epithelial tissue arranged as trabeculæ, columns and irregular masses of cells separated by connective tissue and sinusoidal capillaries. The *pars intermedia* is also epithelial in character; it is closely applied to the posterior lobe, but is separated from the anterior lobe by a narrow split. The two lobes can be separated from the frozen gland by cutting the gland into two parts through the median plane and then lifting the lobes from the capsule by forcing the handle of a scalpel between them, when they can be dropped into ice-cold acetone. If required in the form of powder, the glands are taken from the acetone and cut into small pieces which are allowed to stand in fresh acetone; the pieces are then powdered in a mortar, dried *in vacuo* in a desiccator, extracted by acetone in a soxhlet, dried and stored *in vacuo* over phosphorus pentoxide.

Constituents. The **posterior lobe** contains two substances which have been obtained separately in fractions prepared from extract of the posterior

lobe; these have been named oxytocin and vasopressin respectively. There is some evidence to suggest that both of these are amines and oxytocin is sometimes now named α-hypophamine and vasopressin is named β-hypophamine. Oxytocin increases the rate of rhythmic contraction of the uterus, while vasopressin contracts the smaller arteries and raises the blood pressure. The posterior lobe also possesses the property of stimulating peristalsis and of inhibiting diuresis (anti-diuretic property); these effects may be due to other active constituents or may possibly be related to the vasopressor activity. The anterior lobe contains several hormones which are responsible for at least six different effects upon the body metabolism. These are a growth hormone; a gonadotrophic hormone which may consist of two principles both of which act on both the male

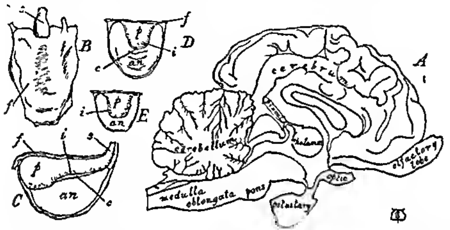

FIG. 199. Pituitary gland of ox, *Bos taurus*. *A*, sagittal section of brain of the ox to show position of the gland (modified after Sisson). *B*, upper surface of isolated pituitary gland. *C*, median section of the gland. *D*, transverse section near the centre of the gland. *E*, transverse section of hinder end of a gland. *an*, anterior lobe; *c*, cleft between the anterior lobe and the remainder, *f*, fibrous membrane between the gland and the base of the brain; *i*, pars intermedia, *p*, posterior lobe, *s*, stalk. (*B*, *C*, *D* and *E*, natural size.)

and the female sex organs; a thyrotrophic hormone which helps to maintain the normal functions of the thyroid; a lactogenic hormone which indirectly controls the secretion of milk; a diabetogenic factor which prevents waste of carbohydrate reserves, and a suprarenal-cortical-stimulating factor

OX GALL. Ox Bile, Fel Bovinum

Source. Ox gall is the liquid contained in the gall-bladder of the ox *Bos taurus* Linn., family Bovidæ.

The gall-bladder of the ox is a pyriform bag, about 18 to 20 cm. long and 5 to 6 cm. wide at the widest part, attached to the under surface of the liver. It receives the secretion from the liver and discharges it into the duodenum; this action is continuous, but is increased by the arrival of food in the duodenum Bile appears to exercise a favourable influence upon pancreatic digestion by increasing the rate of action of the pancreatic enzymes; see Fig. 200.

Description. Fresh ox bile is a brownish-yellow or brownish-green, rather viscous liquid with an unpleasant odour and disagreeable, bitter

taste. It is neutral or faintly alkaline in reaction, has a specific gravity of about 1·022 and is characterised by the following reaction: To 10 mils of a 5 per cent. aqueous solution of ox bile add a drop of solution of sucrose (1 in 4), then gradually 10 mils of phosphoric acid (sp. gr. 1·75) and heat on a water-bath; a deep violet colour is gradually developed. This reaction is due to the action of furfuraldehyde (from the phosphoric acid and sucrose) upon cholalic acid (produced by the phosphoric acid acting upon taurocholic and glycocholic acids). (This is a modification of Pettenkofer's test.)

Constituents. Ox gall contains the sodium salts of taurocholic and glycocholic acids together with colouring substances (bilirubin, biliverdin), mucin, lecithin, cholesterol, fat, soaps, etc., in aqueous solution. In making extract of ox bile the mucin is usually removed by precipitating with alcohol and the filtrate evaporated to a thick extract.

Uses. Ox gall is given in cases of deficiency of bile. It is also used by some bacteriologists in preference to sodium taurocholate for the preparation of certain culture media.

PEPSIN. Pepsinum

Source. Pepsin may be prepared from the mucous membrane of the stomach of domesticated animals such as the pig, sheep or calf; it is most usually prepared from the stomach of the pig, *Sus scrofa* Linn., family Suidæ.

The stomach has an outer muscular coat and an inner mucous surface. When it is empty and therefore contracted, the inner coat is thrown into numerous folds, hence the mucous surface exhibits a rugose appearance. This surface is covered by a single layer of epithelial cells, which also lines the innumerable pits with which it is furnished. Each pit is about 0·2 mm. in diameter and two or three very narrow tubular ducts open into its base. The ducts are lined by a layer of epithelial cells of two kinds; the majority of the cells are more or less cubical and are known as central cells. Scattered amongst the central cells are a few oval or rounded cells with dense contents, known as the parietal cells. The central cells secrete pepsinogen and rennin zymogen, which are the precursors or zymogens of the corresponding enzymes, pepsin and rennin. The parietal cells secrete hydrochloric acid which activates the zymogens liberating rennin and pepsin. The gastric juice secreted by the glands contains these and probably other substances which are discharged into the contents of the stomach whenever food enters it. The pepsin converts insoluble proteins into soluble peptones; unlike soluble proteins, peptones are not coagulated by heat or precipitated by nitric acid.

Preparation. The mucous lining of the stomach is either stripped off and minced or it is scraped off; the pulp is placed in water acidulated with hydrochloric acid and is kept at the body temperature—37°—until autolysis has taken place—about two hours—giving a clear liquid containing pepsin and the peptones formed from the mucous tissue. The liquid is filtered and sodium chloride or ammonium sulphate is added until the liquid is about half-saturated with the salt, when the pepsin is precipitated while peptones remain in solution. The precipitate is collected, suspended in water in a dialyser and the salt removed by dialysis. The aqueous solution of pepsin remaining is precipitated by adding alcohol; the precipitated pepsin is collected and dried at a low temperature. Or the solution in the dialyser may be evaporated *in vacuo*, at a temperature below 45°, and the residue powdered.

Pepsin is obtained in scales by evaporating a strong solution to which

some dextrin has been added, painting the syrupy fluid on glass plates and drying.

Description. Pepsin occurs in commerce as a pale yellowish powder, *or in translucent scales or grains with a faint odour free from putrescence* and a slightly saline bitterish taste. It is soluble in water, in physiological solution of sodium chloride and in dilute acids. It contains the enzyme pepsin, *but does not consist of it. It is most active in a fluid about pH 2* (0·2 to 0·5 per cent. HCl) and at a temperature of 40°. The acidified aqueous solution converts insoluble proteins into soluble proteoses and peptones. Its action is *inhibited by sodium chloride and by alcohol, and* is completely destroyed at a temperature of 70°.

Uses. It is employed in dyspepsia caused by deficient gastric secretion.

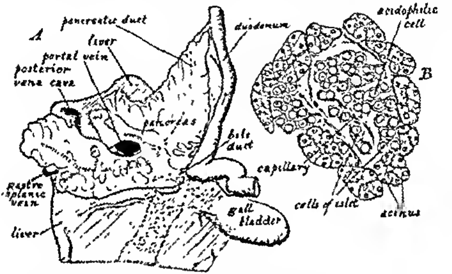

FIG. 200. Pancreas of the ox, *Bos taurus*. *A*, general view of the pancreas and the neighbouring structures (modified after Sisson). *B*, islet of Langerhans and some of the acini secreting the pancreatic ferment; numerous zymogen granules are present in the cells of the acini, × 300.

PANCREAS

Source. The pancreas used in medicine is obtained from the pig, *Sus scrofa* Linn., family Suidæ, or ox, *Bos taurus* Linn., family Bovidæ, order *Ungulata*.

Description. The pancreas of the pig is a compact organ lying transversely across the body behind the stomach; in the ox it is a diffuse gland and weighs about 1 kilo. It is yellowish-red or greyish-red in colour and in the pig it consists of three lobes, each of which is formed of numerous lobules. *Each lobule is composed of groups of small branching tubules* lined with a secreting epithelium. The smallest tubules unite to form larger ones and these open into still larger ducts and the secretion eventually enters the duodenum by two ducts the larger of which unites with the bile duct at the point of entry into the duodenum. The cells of the pancreas are stimulated into activity by a hormone, secretin, which is formed in the epithelium of the duodenum and enters the blood stream by which it is carried to the cells of the pancreas. The epithelial cells of the pancreas now secrete a fluid containing zymogens which are conveyed to the duodenum where an enzyme, enterokinase, converts them into the

enzymes trypsin, which digests proteins, amylase, which digests carbohydrates, and lipase, which digests fats. Other substances present in the

stream and regulates carbohydrate metabolism.

Commercial pancreatin is a mixture of these enzymes with other substances obtained by extracting the minced pancreas with water or dilute hydrochloric acid, precipitating with alcohol, collecting and pressing the precipitate and drying at 40°. The precipitate will not be active unless the zymogens in the pancreas have been acted upon by the enterokinase of the duodenum.

Pancreatin is a pale cream coloured powder with a slight meaty odour: it is soluble in water.

Crude insulin may be obtained by extracting the fresh pancreas with alcohol and sodium bicarbonate, pressing and filtering, and fractionally precipitating by alcohol. Crude insulin may be purified by precipitating as picrate, decomposing the picrate with alcohol acidified with hydrochloric acid and precipitating insulin hydrochloride by acetone. Insulin hydrochloride thus obtained is a white, amorphous powder. Insulin has the property of reducing the amount of sugar in the blood, and is employed as a remedy for diabetes. Fresh pancreas yields about 0·2 per cent. of crude insulin.

MUSK. Moschus

Sources. Musk is the dried secretion from the preputial follicles of the musk deer, *Moschus moschiferus* Linn. (Phylum *Chordata*, class *Mammalia*, order *Ungulata*, family Cervidæ).

Collection. The musk deer is a small, graceful animal about the size of the roebuck, and inhabits a large area in Central Asia, extending from the Caspian Sea to the eastern boundaries of the Chinese Empire. The male animal, which alone produces the musk, bears on its belly, a short distance behind the navel and just in front of the preputial orifice, a small sac produced by an infolding of the skin. This sac is the musk sac or musk pod, and it contains a treacly or soft, unctuous, brownish substance, musk, which is remarkable for its intense, penetrating, and persistent odour.

secretion, debouching close to the preputial orifice. Very young animals do not secrete musk and old animals but little.

The animals are snared or shot, and the musk sacs cut out, trimmed and dried, when they are known as "pods"; they are then wrapped singly in paper and packed in a small rectangular box covered with silk. This box is known as a "caddy" and contains a "catty" (21⅜ ounces) of musk pods (about 22). Of late musk pods have been packed in flat tins each containing two catties.

or from
ed down
Smaller

quantities are obtained from the southern Chinese province of Yunan (Yunan musk), and some finds it way viâ Nepaul or Assam to Calcutta (Nepaul musk, Assam musk)

The musk pods are examined in China and classified into three qualities, or "piles" as they are termed. In London they are again examined,

probed with a knife, etc., and again classed into piles, pile 1 consisting of genuine pods, whilst those of pile 2 are obviously sophisticated.

Description. The best variety of the drug is that known as Tonquin. This is imported in pods packed in "caddies" or latterly in larger tins. The pods are nearly circular or oval in outline and nearly hemispherical; they are about 5 to 7 cm. in diameter and 2 to 3 cm. thick. The convex surface of the pod bears numerous brown or brownish white hairs and is part of the hide of the animal; it exhibits a nearly central small orifice near to which the hairs are naturally short, but those a little distance removed have been clipped and are stiff and bristly. The flat surface of the pod is covered with a very thin, soft, supple membrane, and appears dark brown in colour when the pod is filled with musk. It often exhibits a fine steel blue iridescence, whence the term "blue skin," by which this variety of Tonquin pods is known. This thin blue skin is the inner skin of the pod, the outer skin, which is tough and fibrous, having been carefully stripped off. By this means the appearance of the pod is improved and its value enhanced. Good pods weigh about 25 to 35 g., and contain about half that weight of granular musk which fills them loosely.

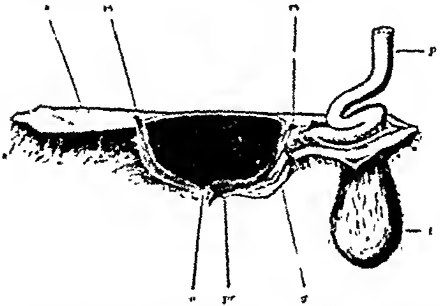

FIG. 201. Musk pod and generative organs of the male musk deer. *s*, skin; *p*, penis; *t*, scrotum; *g*, gland of the penis; *pr*, preputial orifice; *o*, orifice of the musk sac; *m*, muscular coat of musk sac. (Moeller, after Brandt.)

The musk contained in the pods is usually moist, and often has a strongly ammoniacal odour. It can be freed from moisture and ammonia by exposing it to the air, and then forms dark reddish-brown unctuous grains ("grain musk") with which occasional short hairs are mixed; it possesses a strong characteristic odour and bitter taste.

Constituents. Musk yields by distillation with steam and subsequent purification a small percentage of a viscid colourless oil with a very powerful and agreeable odour of musk; this oil appears to be a ketone and has been termed muskone. The drug contains moisture, fatty matter, resin, proteins, and inorganic substances. Water dissolves from 50 to 75 per cent. of it, but alcohol only 10 to 12 per cent. It should not contain

The commercial exploitation of a crude drug leads to a demand for regular supplies in sufficient amount and of uniform potency and if the demand is large enough, efforts at cultivation are almost certain to follow. For this purpose knowledge of the geographical source and of the particular environment favourable to the plant is needed. The nature of the soil, the altitude at which the plant grows, the type of atmospheric conditions—such as moisture, temperature and protection from wind—must be studied. For example, in selecting localities for the cultivation of cinchona, those in India were as suitable from most points of view as those in Java, but the trees—*C. Calisaya* and its varieties—which yielded the highest percentage of quinine did not grow well in the soil of the Indian plantations, while in Java the volcanic nature of the underlying rock produced a porous soil in which the more valuable type of tree grew strongly and so the cinchona trade eventually became established in Java rather than in India. Another rather different instance is found in the cultivation of *Hydrastis canadensis*, which is a [illegible] the shade of a canopy of trees, and [illegible] ell in cultivation in the open field; [illegible] surmounted by erecting, at a height of 5 to 6 ft. above the ground level, a staging of lattice work, which produces a shade similar to that of the natural woodland

Knowledge of the geographical source also assists in the identification of the biological origin, because it is generally known that plants of a certain type come from particular districts and one may often exclude from consideration entire families of plants as well as individual species, or one may deduce the possibility that the drug may be derived from a plant belonging to one of some few families characteristic of the region

Cultivation of drug-yielding plants is advantageous from many points of view.—

1. It affords a valuable method of control of the purity of the product. It is, for example, very difficult to free small fruits, such as those of the Umbelliferæ, from weed seeds once the crop has been harvested; but by careful weeding during the cultivation of dill, fennel, caraway and other similar plants, the purity of the finished product is assured. Drugs such as the roots of aconite and belladonna, which are liable to admixture with other roots when collected from wild plants, will be of uniform purity if cultivated. Cinchona also, when collected from wild trees in the mixed forests of the Andes was often mixed with foreign barks, owing in part to the difficulty of identifying the scattered trees; this type of adulteration is entirely avoided by cultivation

2. The processes of collection, drying and storage can be adequately controlled on farms and plantations, where the operations are carried out by trained workers instead of being left to the casual treatment of unskilled collectors Leaves like digitalis and the solanaceous drugs can be collected when in the best condition and rapidly dried in artificially heated chambers, all under skilled supervision, chamomiles and other flowers can be collected as they come to the proper stage of flowering and then dried so as to retain their colour; drugs like

cinnamon which undergo special treatment during preparation are of better and more uniform quality when obtained from plantations and prepared by workers who are accustomed to the processes.

3. **Improvement of the drug** by control of certain factors in cultivation has frequently been effected. For example, by *sorting the seed* of digitalis and sowing only the heavier seed, the plants raised were more sturdy and a better yield of leaves was obtained. By applying *farmyard manure* and *nitrates* to crops of solanaceous plants the amount of alkaloid in belladonna, henbane and stramonium was doubled and the yields increased by 20 to 30 per cent. By raising *hybrid cinchonas*, the proportion of quinine in the bark has been greatly increased and the strain of tree has been kept true by cultivation by grafts. Continued cultivation and *selection of the best qualities* for propagation has resulted in great improvement of the flavour of cinnamon and also of celery fruit and other similar fruits. The choice of localities with a particular type of *climate* also enables the cultivator to obtain a product with specially desirable qualities; thus ginger cultivated in Jamaica has an aromatic flavour superior to that from other countries, while the same plant cultivated in Africa yields a much more pungent product, and these two varieties are commercially valuable in different industries. *Cannabis sativa* is another example: it yields a high proportion of resin when cultivated in tropical countries like India, but a lower percentage of resin and a larger amount of fibre in the stems when grown in temperate countries.

Examination of *polyploid* varieties of medicinal plants, obtained by treatment of the seeds with colchicine, has shown that the alkaloidal content of belladonna can be doubled and that of henbane increased by about one-third, while for species of *Datura* increases of from one-third to two-thirds have been obtained (Rowson, 1945).

4. As a result of improvements or modifications effected in several instances by methods of cultivation, certain drugs are now **obtainable from cultivated plants only**. Such drugs are chamomiles, which consist of doubled flowers and are therefore only to be obtained by cultivation and must be propagated by cuttings. Cinnamon and celery fruit are other examples, the flavour of the product in each case having been so greatly improved by cultivation that drugs from wild plants are now inadmissible. Variations resulting from habitat have a similar effect and the more desirable varieties carry a higher market value, as with Penang cloves, and in some cases, such as Jamaica ginger and African chillies, are prescribed for medicinal use.

5. Production of drugs by cultivation assures a **regular and constant supply** and has helped in several instances, such as cinchona, cloves and nutmegs, to *break down monopolies* and so render the drugs concerned both cheaper and more readily accessible. Drugs like cinchona and psyllium, for which a great demand arose quite rapidly, could not be obtained in sufficient quantity when the market was dependent upon the produce of wild plants and in both instances cultivation has been resorted to so as to maintain regular and sufficient supplies.

6. Cultivation of drugs in *proximity to the factory* for the manufacture of galenicals is often a distinct advantage, especially for making fresh green extracts such as green extract of belladonna. The fresh drug

can be taken directly from the field into the factory for immediate use, thus preventing deterioration of the drug by careless handling or by temporary storage. The yield and quality of the products are improved and are more easily controlled, while economies are effected in labour and in transport. The drying of cultivated drugs in such a factory can also be arranged under the most advantageous conditions, thus avoiding the incidence of decay of the cell contents, a condition which rapidly supervenes when there is an interval between collection and drying.

7. Indirectly, cultivation makes contributions to pure science. Such subjects as the rôle of alkaloids and glycosides in the life of the plant; the influence of manures on the growth of plants and the amount of their constituents; and the control of diseases attacking plants under cultivation can all be studied. Information relative to morphology, such as the variation in external features and histological details resulting from cultivation and hybridisation is also rendered available.

Cultivation of medicinal plants will tend to increase for various reasons, mostly economic in character. One important factor is the gradual decrease in the supply of cheap manual labour. The cost of collecting wild plants will therefore tend to increase until a point is reached at which it becomes more economic to cultivate them. The spread of agriculture in all parts of the world is steadily decreasing the amount of wild, untouched vegetation and is also involving the deliberate destruction of medicinal plants, either because of the risk of poisoning resulting from their presence on agricultural land, as in the case of belladonna, or because they are troublesome, easily disseminated weeds, as in the case of dandelion.

The fact that many medicinal plants occur scattered sparsely throughout a mixed vegetation also provides a strong incentive to cultivation, which completely removes the difficulty of finding and recognising the correct plants and in most cases results in a more economic production of the drug. There are, however, certain factors, which always lead to restriction of cultivation. Wherever abundant cheap labour is available, as in tropical Africa and other of the less civilised countries, the collection of drugs like strophanthus can be carried out cheaply and efficiently under a general but quite limited supervision. Also when drugs are collected in spare time by persons like shepherds, whose regular employment takes them over wide stretches of ground without fully occupying their attention, it is economically possible to obtain supplies of such drugs as gentian, veratrum and arnica, which grow on the mountains of central Europe. There are two other important factors, and these are, firstly, that certain drugs are required in comparatively small quantities, and, secondly, that cultivation can only be economically successful when carried out on a large scale. Hence drugs like male fern and strophanthus, both of which are required in small amounts, are unlikely to be produced by cultivation under present conditions. A further difficulty, operating in a few instances, is the peculiar habitats of certain plants, habitats which are difficult to reproduce artificially, such, for example, as the sphagnum bogs on which *Drosera* grows and the dense tropical forests in which a climbing plant like strophanthus is found naturally.

Although there are many advantages resulting from the adoption of cultivation of drug-yielding plants, this method is subject to certain definite drawbacks. One of the most serious is the spread of disease amongst closely growing plants of the same species and one may instance the attack of belladonna by a fungus of the genus *Phytophora*,

varieties produced by allied species become very difficult to distinguish.

FIG. 202. Sampling a few bales of bark at the London Dock (Heap)

TRANSPORT AND MARKETING

Drugs imported into this country come chiefly to London which is the centre of distribution for Great Britain and also in many instances for the continent of Europe also. There are many docks in the Port of London, but the great majority of drugs come into the London Dock where the steamers are unloaded at the quayside, a certain amount of cargo from large ships is unloaded into barges lower down the Riv
in the
comes
lower down the river. Most
foreign countries to brokers,
Lane and its neighbourhood
from abroad, not merely in

foreign drug merchants advise the broking firms of the despatch of the goods and when a cargo arrives the brokers concerned obtain samples of the merchandise, and at suitable times, usually just before the sales, "drug shows" are arranged in the brokers' offices by setting out samples of the goods for sale upon their counters. Prospective buyers attend these "drug shows" and make notes of the parcels they wish to buy and the prices they are prepared to offer; frequently also they take samples for examination. On the day following the "show," the goods are sold by auction at the drug sale which is held in a large

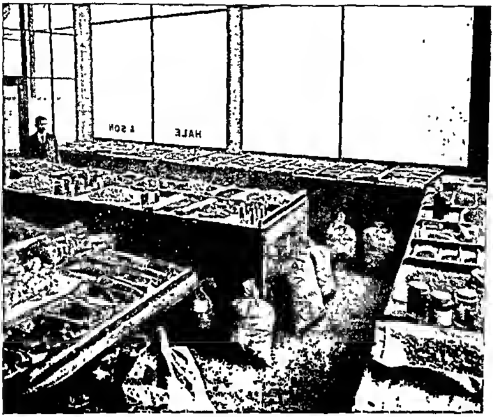

FIG 203. Sale room of Messrs Hale & Son On the centre and window-tables various drugs, on the table to the left chiefly bristles, on the floor sample-bags of drugs (Heap)

Sales Room in Mincing Lane. The actual goods are stored in warehouses alongside the wharf at the docks and also in a warehouse at Cutler Street; a certain amount of merchandise is on show at these warehouses and is visited there by the buyers who often take samples for assay.

In preparation for the sales each broker issues a list of the goods on show at his office or at the warehouses, and these are marked hy the buyers when examining the specimens exhibited. At the auction the brokers offer their goods, taking the stand in the order noted at the right-hand top corner of the sales list. Often much merchandise is not disposed of at the actual sale and is frequently sold afterwards by private arrangement in the passages about the Sales Room or in

the street—"on the kerb" as it is termed—the price arranged being known only to the buyer and seller.

Some drug producers sell their produce to dealers in the country of production and these often deal directly with the buyers both in London, New York, Amsterdam and Hamburg The larger amount of drugs, however, passes through the hands of the brokers, thus

FIG. 204. Cases of Chinese rhubarb on show at the Cutler Street Warehouse The small trays contain rhizomes which have been broken open to show the colour and condition of the interior (Greenish)

enabling the buyers to form a better opinion of the value of the goods they are purchasing.

Other British ports to which large amounts of drugs are brought are Hull, Liverpool and Southampton To Hull come cargoes from the Baltic and Scandinavia, oil seeds forming the bulk of the imports; similar cargoes also come from India, Egypt, Brazil and China. To Liverpool there comes produce chiefly from West Africa, South America and the United States of America and to Southampton chiefly from South Africa. The most important continental ports to which drugs are sent are Amsterdam, which receives drugs from Java

and the East Indies, especially cinchona, coca leaves, nutmegs, cloves, mace and cinnamon, and Hamburg to which a great variety of produce is sent.

Many drugs were formerly sorted and graded at the docks and some are still so treated. Such consignments of drugs are said to be "worked," a term which includes both bulking and garbling. By **bulking** is meant that the packages are emptied on to the floor of the warehouse and the contents mixed and repacked; this is often done with cardamoms, tragacanth, pepper and tea. Other drugs are "**garbled**," that is to say, the consignments are picked over carefully to remove extraneous matter, and are then sorted into different grades,

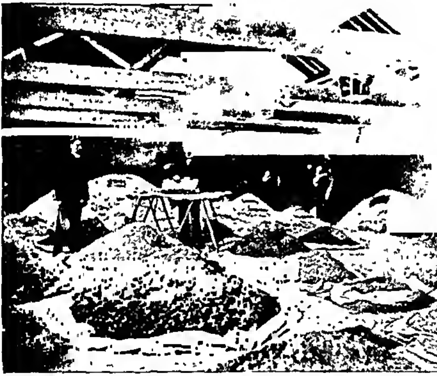

FIG 205 Working tragacanth. (Heap.)

which are finally repacked and offered at varying prices. Rhubarb, nutmegs and myrrh are examples of drugs which are often "garbled" at the docks. Much further cleaning and picking over is done at the warehouses of wholesalers to remove extraneous matter and to produce grades. For example, a bale of senna leaves is put on to a mechanical shaker and sifter which divides the contents of the bale automatically into pods, leaves and dirt, each of which is delivered by the machine into a special container. Other examples are calumba root, which is usually washed and redried by the wholesaler, and rhubarb which is trimmed and dusted with powdered rhubarb. As a result of these operations very few drugs arrive in the hands of the pharmacist or distributor in the condition in which they were imported, but have usually been graded or bulked at some stage of marketing.

ACQUISITION OF DIAGNOSTIC CHARACTERS

During the treatment to which drugs are subjected in the stages of cultivation, collection, packing and marketing, important diagnostic characters are often given to the commercial article. As a result crude drugs frequently exhibit notable features which are quite unrelated to the plants or animals which yield them. A number of such instances may be briefly summarised.

Drugs collected from wild plants often differ from those from cultivated plants because of modifications resulting from the cultivation itself or from the methods of collection. Thus cinchona from large trees in the Andes is often in very large pieces known as "flats" or in heavy quills, while cultivated bark is in medium or small quills or, in the case of root bark, in small pieces. Cinnamon from wild trees is a heavy bark with a coarse flavour; that from cultivated plants is in small quills with a more agreeable flavour. The root of cultivated aconite is usually collected in the autumn after the stem has died down and hence English root, which is mainly cultivated, consists of plump tubers with a bud at the summit. German aconite is usually gathered from wild plants in flower, and hence is more shrunken and has the base of the stem attached above and may also sometimes have a small daughter root at the side. Digitalis, collected from cultivated plants, consists of leaves only, collected individually; belladonna, stramonium and hyoscyamus are collected with the tops, including flowers. Galbanum and asafetida, though not obtained from cultivated plants, contain fruits and slices of the roots, characters resulting from the [illegible]

[illegible] to a drug, [illegible]d incisions [illegible]aracteristic markings.

Scraping and similar processes resulting in the removal of outer tissues give marked characters to drugs such as cinnamon, quillaia, ginger, marshmallow root, rhubarb, liquorice, colocynth and white pepper. The treatment of cinnamon in preparation results in the production of a very thin bark in small quills and makes evident the longitudinal yellow lines—small bundles of pericyclic fibres—on the outer surface. Colocynth from different sources may be recognised by the variation in treatment, thus whole unpeeled colocynth comes from Mogadore, peeled unbroken fruits from Turkey, while peeled and broken fruits come from Egypt.

Slicing preparatory to drying necessarily imparts marked features to a commercial article. Examples are calumba, dried colchicum corm, ipomœa, squill and sometimes jalap which are sliced transversely, and belladonna root, valerian, veratrum and sometimes ginger, which are sliced longitudinally.

Bleaching alters the appearance of certain plants and drugs when they are being prepared for the market. *Chondrus crispus*, a red seaweed, appears in commerce as a pale cream coloured drug. White beeswax also is produced by bleaching. A different kind of bleaching is applied to some commercial varieties of ginger, orris and nutmeg,

which are coated with a layer of calcium carbonate or sulphate, a custom which is undesirable.

The **method of concentration of fluids** and the type of mould used to contain them while cooling, give to certain products important characters. Hepatic varieties of aloes acquire their opacity by a slow process of evaporation, resulting in the formation of multitudinous small crystals, while the vitreous kinds owe their transparency to rapid concentration of the fluid, which gives an amorphous product. The **type of mould** imprints characters on certain drugs as in the case of gamboge, which shows longitudinal striations caused by the fibrous strands on the inner surface of the hollow bamboos in which the gum-resin is allowed to solidify. Similarly black catechu and some specimens of socotrine aloes have leaves adhering to the exterior, because the moulds into which the fluids are poured are lined with leaves. Sheet gelatin is dried on wire-netting and elaterium on muslin and the impress of the material is seen in each case on the surface of the commercial article.

Treatment in preparation for packing and transport gives notable characters to several drugs. The characteristic transverse lines on leaflets of Indian senna and on twigs of ephedra result from the strong compression used in making the bales. Indian hemp in the form of "guaza" is flattened by the pressure of trampling feet and in the form of "ganjah" is rendered more or less cylindrical by rolling under foot or in the hands. *Zanzibar aloes is poured into skins of small carnivorous* animals in preparation for export and pieces of skin in the drug indicate its source. Opium from Turkey is now usually imported in cylindrical cakes covered with a coating of coarsely powdered poppy leaves, while Persian opium is in rectangular blocks wrapped in paper, often brightly coloured.

Enzyme action, encouraged during the preparation of the drug, is responsible for giving new and marked characters to particular drugs such as gentian, valerian, vanilla, tea and cola.

DETERIORATION AND STORAGE

The **fundamental influences** which are responsible for the deterioration of drugs and which must be considered in relation to storage are humidity, light, temperature and the oxygen of the air. The **more visible agents** of deterioration arise secondarily as a result of growths, which can occur only under certain conditions of humidity and temperature and upon material providing a suitable nutrient substratum. There are in the atmosphere innumerable spores and germs which settle upon all exposed surfaces in the form of dust and, if the humidity and temperature are suitable, they will quickly germinate and develop into organisms, such as bacteria, moulds, mites and insects, all of which will attack drugs when conditions are favourable. As protoplasm cannot exist without sufficient moisture, it is a suitable degree of humidity which most largely affects the development of these living organisms. The other important factor is temperature, which must be higher than about 10° C. if organisms are to grow and multiply freely. All these points need to be kept in mind when questions of

storage are being considered with a view to preventing deterioration of the stock.

Moisture alone is sufficient in many instances to affect drugs adversely. The active principles of digitalis and of ergot undergo rapid change, resulting from the presence of enzymes, which only need a sufficient degree of moisture to activate them, and in the case of digitalis this is any amount over 5 per cent Starch, gelatin, squill and other hygroscopic materials quickly become deteriorated by absorbing considerable amounts of moisture from a humid atmosphere. **Light** adversely affects many drugs, especially those possessing marked colour. Rhubarb rapidly changes from yellow to a reddish tint; petals of rose, flowers of henbane and other coloured or white corollas quickly turn brown; digitalis also loses its activity more rapidly in sunlight, and santonin slowly darkens to orange and eventually becomes black. **Polarised light** has been shown to produce changes more rapidly than ordinary light and, as reflected light is always to some extent polarised, direct sunlight reflected on to drugs in store will bring about rapid deterioration It has been shown, for example, that polarised light rapidly brings about the decomposition of the active principles of digitalis in its tincture. **Temperature** has marked effects, sometimes unsuspected Many enzyme changes proceed more rapidly at a slightly raised temperature and similar conditions will often induce molecular rearrangements. A good example of the latter condition is that of absorbent cotton, the molecules in the slight residue of fatty matter of the cuticle gradually become reoriented in such a way that water cannot penetrate the extremely thin film and the cotton, once fully absorbent, loses this property and eventually becomes entirely non-absorbent, this change is much hastened by raising the temperature slightly above the normal air temperature. Other drugs directly affected by temperature are those containing volatile oils, such as buchu, chamomile flowers, ginger and asafetida. Direct oxidation of constituents of drugs is sometimes brought about by the **oxygen of the air**; thus linseed oil and the cannabinol of indian hemp rapidly become resinified; oil of turpentine and oil of lemon also experience a similar change. Colophony, if powdered, quickly alters in constitution and becomes much less soluble in light petroleum, apparently by a change in the abietic acids.

In addition to these changes due directly to environmental factors, there are also the more visible secondary effects produced by the development of living organisms in drugs. The more common of such organisms belong to the groups bacteria, moulds, mites, nematode worms and insects. The effects produced by bacteria are not always very visible, but in the case of the chromogenic species, their presence is quickly recognised. For example, *Bacillus (Chromobacterium) prodigiosus* produces red patches on bread, paste, potatoes and other starchy materials. For other bacteria, the effect of their presence is not immediately evident. This happens with cotton fibres, which are eventually rendered very brittle by bacterial attack, thus causing the trichomes to break into short lengths, which make the cotton-wool objectionally dusty. The **moulds** most frequently present are those found attacking foodstuffs as well as drugs and belong chiefly to the

groups *Mucor*, *Penicillium* and *Eurotium*. The mycelium of delicate hyphæ produces an unpleasant mass of clinging particles in powdered drugs and in such materials as Lycopodium, which have become damp.

The variety of mould can be recognised by its fructifications, which are carried upon vertical branches arising from the mycelium. *Mucor*,

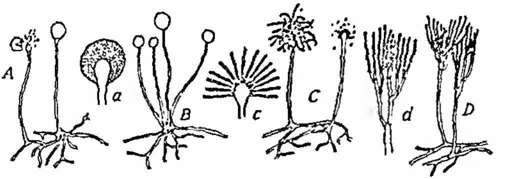

Fig. 206. Fungi which cause mouldiness in drugs. *A*, *Mucor mucedo*, grey mould. *B*, *Rhizopus nigricans*, black mould. *C*, *Eurotium repens*, green mould. *D*, *Penicillium glaucum*, blue mould. All × 200. *a*, *c* and *d*, sporing heads of *Rhizopus*, *Eurotium* and *Penicillium* respectively. All × 400.

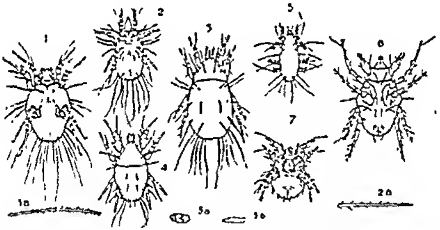

Fig. 207. Mites which attack drugs. 1. *Glyciphagus spinipes*, Koch. 2. *Tyroglyphus longior* Gervais. 3. *Tyroglyphus siro* Linn, common cheese mite. 4. *Aleurobius farinæ* Koch, common flour mite. 5. *Histiogaster entomophagus* Laboulbene. 6. *Cheyletus eruditus*, Schrank, carnivorous mite. 7. *Glyciphagus fuscus* Oudemans. *3a*, egg, and *3b*, empty egg case of *T. siro*. *All × 30. 1a and 2a, hairs of G. spinipes and T. longior* respectively. Both × 150. 1, 2, 3 and 4 after Michael; 5, 6 and 7 after Newstead and Morris.

grey mould, and *Rhizopus*, black mould, have a spherical sporangium containing very numerous minute spores; *Penicillium*, blue mould, produces long strings of spores arising from the tips of branches of the upright conidiophore and *Eurotium*, green mould, has an unbranched conidiophore bearing a mop-like head of strings of spores; see Fig. 206.

Mites and sometimes nematode worms may also be found infesting drugs in large numbers. The mites are those commonly found in foodstuffs and include *Tyroglyphus siro*, the common cheese mite;

Aleurobius farinæ, the flour mite; and *Glycyphagus spinipes*, which sometimes swarms on cantharides. The mites belong to the same group of animals as the spiders and can be recognised under the microscope by the possession of four pairs of legs (three pairs in the larva) and by the more or less oval form of the body, which shows a division into two parts, named respectively the cephalothorax (corresponding to the head and thorax of an insect) and the abdomen. The mites appear as glistening, bladdery specks, just visible to the naked eye, in such substances as crushed linseed, wheat flour and oatmeal, in which they multiply very rapidly and frequently swarm in countless numbers. The best known example of a nematode worm is the common "vinegar eel," *Anguillula aceti*, and a second example

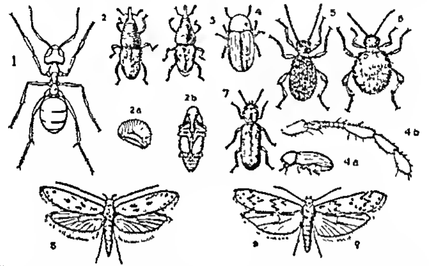

FIG. 208. Insects which attack drugs. 1. *Formica rufa* Linn 2 *Calandra granaria* Linn. 2*a*, larva, and 2*b*, pupa of the same. 3 *Calandra oryzæ* Fab. 4. *Stegobium paniceum* Linn. 4*a*, side view of the same 5. *Ptinus brunneus* Dft. 6. *Niptus hololeucus* Fald. 7. *Lyctus brunneus* Steph. All × 4 8 *Borkhausenia pseudospretella* Stainton. 9 *Ephestia kühniella* Zeller. Both × 2. 4*b*, antenna of *S. panicea* × 40.

is a similar worm, *Anguillula tritici*, sometimes found in wheat flour. These worms are just visible to the unaided eye as minute threads continually curling and twisting in the medium they inhabit.

Insects of various kinds often occur in large numbers in parcels of drugs. They mostly belong to the moths, Lepidoptera, or the beetles, Coleoptera, but one also finds such insects as cockroaches, order Orthoptera, and ants, order Hymenoptera. Cockroaches (*Blatta sp.*) may infest the premises generally, and nuts, Formicidæ, sometimes occur in such articles as linseed meal. Five small beetles are very common: these are *Stegobium paniceum* Linn. (= *Sitodrepa panicea*), the drug-room beetle; *Ptinus brunneus*, the brown spider beetle; *Niptus hololeucus*, the golden spider beetle; *Lyctus brunneus*, the powder-post beetle; and *Calandra granaria*, the granary weevil These are all quite small insects, being from 2 5 to 8 mm long, and they bore holes into all kinds of materials. The damage is done chiefly by the

larvæ, which, as they feed, bore tunnels into the drugs, produc quantities of fine powder commonly called "pore-dust."

The beetles may be recognised by the following characters :—

Stegobium paniceum Linn. (= *Sitodrepa panicea*), the drug-room beeth oval-oblong in outline, reddish-brown with a greyish or whitish pubescer About 2 to 3 mm. long. The elytra have fine, punctated longitudi striæ. The antennæ are distant at the base and the last three joints enlarged and broader than the preceding ones; the second joint of antenna is twice as long as the third.

Ptinus brunneus, the brown spider beetle, is oval in outline, 2 to 4 n long, brown in colour with a distinct central furrow on the thor The elytra have fairly strongly punctated striæ and there are no whit pubescent patches. The antennæ are contiguous at the base.

Niptus hololeucus, the golden spider beetle, is nearly globular in fo 3 to 4 mm. long and covered with a silky-golden pubescence. The anten are contiguous at the base, long and rather slender.

Lyctus brunneus, the powder-post beetle, is oblong and about 3 5 mm. long, glossy reddish-brown in colour. The prothorax is wider front than behind and has a shallow longitudinal furrow down the cent The first ventral segment of the abdomen is much elongated. The anten are club-shaped, the last two joints being larger than the remainder.

Calandra granaria, the grain weevil, is narrowly ovate and about 2 3·5 mm. long, brownish-black in colour. The head is narrowed in fr and prolonged into a rostrum to which the geniculate antennæ attached. The thorax is about as long as the elytra and is marked w large oblong punctures not very close together. The elytra have de punctate longitudinal striæ. *Calandra oryzæ*, the rice weevil, is simi but is slightly smaller and has two orange-coloured patches at the ap and the base of the elytra.

The most common moths are *Borkhausenia pseudospretella*, *Ephest kuhniella*, the Mediterranean flour moth, and *Plodia interpunctella*, t Indian meal moth, all of which belong to the family Pyralidæ and a grey in tint. The moths themselves are unable to damage drugs, b they lay their eggs in the dried vegetable material, and the gru which hatch out feed upon the drug and rapidly reduce it to powde They attack such materials as valerian root, henbane leaves ar poppy heads.

The most common of these moths is *Borkhausenia pseudospretell* which can be quickly recognised by the fore-wings, which are pale browni and marked by three large fuscous spots near the centre, the hinder marg and the apical third of the costa are spotted with dark fuscous. Th moth with closed wings is about 10 mm. long and the head has lar curved and ascending labial palpæ. The neuration of the wings is al characteristic.

These various animal pests produce quantities of droppings, whic form a good nidus for the growth of bacteria and moulds, and as result the whole stock soon becomes an unpleasantly smelling mas of crumbling drug containing much powder largely formed int clinging masses held together by fungal hyphæ or the webbing spu by caterpillars about to pupate. Materials which have thus becom badly infected are best destroyed by burning, and the store places i

Premises and goods which have become infested by insect and similar pests can be freed from them by some form of fumigation, the most effective method being the use of hydrocyanic acid. For the treatment of small rooms, cupboards or boxes, the most generally useful fumigant is carbon disulphide, which is applied by placing a saucer containing the liquid, or a piece of cotton-wool soaked with the liquid, upon the top of the articles to be fumigated in a large box or chamber, which can be securely closed; the heavy vapour of the liquid falls down and penetrates the contents of the box, destroying the insects which infest them. A suitable amount of carbon disulphide is about 1 fluid ounce for every 10 cubic feet, and the box should be left closed for about forty-eight hours. Owing to the

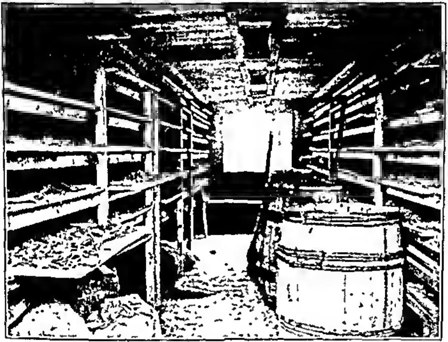

FIG 209 Drying dandelion root by hot air. Note the barrels for storage of the dried drugs.

highly inflammable and explosive nature of the vapour and its unpleasant odour, the fumigation chamber should be kept in the open air and away from any possible contact with flame

Drugs are maintained in a sound condition by adopting proper methods of storage, and a study of the causes of deterioration enables one to perceive the general principles which must govern conditions of storage. It is clear that dryness is the most fundamental requirement, since no living organism can exist or develop without a minimum of moisture; for example, it has been shown that mites are unable to develop in flour if the moisture content is maintained below 11 per cent. (Newstead and Morris, 1920) and that a moisture content below 9 per cent prevents the growth of bacteria and fungi upon cotton-wool (Preston, 1933). Next to moisture, light and temperature should be controlled and the access to the drugs of spores and of living

nisms must be prevented. These conditions may be satisfied by rent means, and the exact method adopted for any given drug not necessarily be the same in all circumstances. Wholesale lies and cultivators' stores may be satisfactorily controlled by iods which are quite unsuitable for use by a retailer. For example, es of dried leaves or roots can be safely kept by the grower or lesaler in large loosely closed containers, such as barrels or bins, ie drying room itself; but as soon as they are to be transported where it becomes necessary to consider the type of container for ing and storage in places where external conditions are continually ing. Well-closed opaque containers fulfil most of the necessary itions, additional precautions being adopted for specially sensitive erials. Much depends upon the rate at which supplies are used, where the demand for a drug is so small that an ordinary container remain more or less filled for many months or even years it is ssary to provide some means of controlling the humidity within container, which will be affected every time some of the drug moved for use; this applies notably in connection with drugs like dered squill, digitalis and ergo [illegible] difficulty; one is to store the [illegible] d containers, as is often done [illegible] tain a dry atmosphere by th [illegible] klime, a method which is particularly useful for powdered squill for drugs possessing delicate colours such as occur in the petals of ers. A common plan is to use a bottle having a wide mouth and a hollow stopper into which the quicklime is put and is kept in by cover [illegible] with a piece of chamois ier. The [illegible] in be largely prevented ho use of [illegible] is preferred to metal or r opaque material and when it is inconvenient to store the bottles dark room. Generally speaking, it seems better, when making in relation to storage, to specify the kind of environment which ld be maintained, rather than to require the use of some particular of container.

ie fact that a raised temperature facilitates the production of a atmosphere may cause one to overlook the other deleterious ges that the heat may produce, for it is often necessary to store les in a cool place as well as in a dry atmosphere. This applies ich materials as cotton-wool, chamomiles and other commodities aining volatile oil; it is, in fact, generally desirable that a store should be cool as well as dry. A low temperature is also useful revent the development of spores and eggs which, generally speak- are unable to develop unless the temperature is higher than about C. For this reason cold storage in some form of refrigerator is a able means of preventing the development of living organisms in inds of drugs and enables one to store large stocks of substances h are particularly prone to attack.

ADULTERATION AND ITS DETECTION

any methods have been and are still used for the adulteration of e drugs. In general, adulteration occurs when a drug is scarce or

when the price of a drug is normally high, though there may be no scarcity. The adulterant must be some material which is both cheap and available in fairly large amount. Availability and price limit therefore the range of substitute from which the adulterator can select suitable material. Consequently, if one keeps a record of adulterants, which have occurred from time to time, the list is almost certain to include any material that is likely to be so used at the present time. Another factor to bear in mind, when making records, is that these [illegible] ...dition to [illegible] examplo, [illegible] consist- [illegible] ecords of adulterants used for tea will includo practically all likely materials, and [illegible]

general texture of the powder which aro more important than external macroscopical resemblanco. Hence, with powders, one must remember that the powder may have been made from an adulterated unground drug or somo powdered material may havo been mixed with powder of a genuine article. Hence tho adulterant may bo any kind of material, not necessarily belonging to the same morphological group as that of tho genuine drug, for example, powdered guaiacum wood has been used to adulterate powdered nux vomica and dextrin to mix with powdered ipecacuanha.

Tho methods used for adulteration may bo grouped as follows :—

1. Manufacture of substitutes. Materials are artificially manufactured so as to simulate the general form and appearance of various [illegible]

imitated by compressing powdered chicory to the shape of coffee berries Paraffin wax coloured yellow has been substituted for beeswax [illegible]

[illegible] nercial varieties For example, [illegible] senna) and Provence senna (*C. auriculata*) have been used to adulterate senna ; Cochin, African and Japanese ginger to adulterate ginger, Smyrna tragacanth and hog tragacanth as substitutes for tragacanth, *Capsicum annuum* fruits and Japanese chillies for fruits of *Capsicum minimum* and fruits of various species of *Piper*, *e.g.*, *P. Clusii* and *P. lowong* for cubebs.

3. Substitution of exhausted drugs. Some commodities are used in very large amounts for the manufacture of preparations after which the vegetable residue retains very much tho appearance of the original material. Sometimes as in tho preparation of volatile oils from cloves or from umbelliferous fruits such as caraway and fennel, the unground

sidered :
about
un *hispidus*
or Indian
ser ecies of
Barosma mixed with buchu ; conium fruit adulterating anise, or Indian or rhapontic rhubarb replacing Chinese rhubarb.

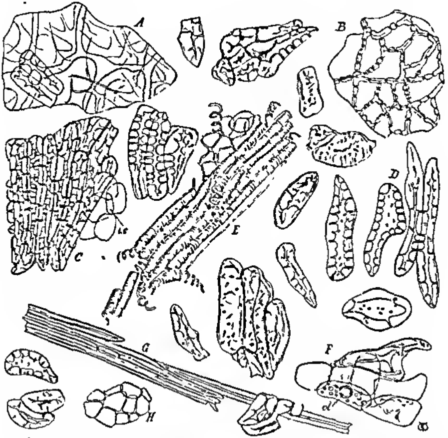

FIG 210. Olive stones. *A*, epidermis and collapsed layers of the testa *B*, epidermis of endosperm of seed *C*, innermost layers of stone cells of the endocarp (stone). *D*, isolated cells from inner layer of the stone. *E*, vascular strand from the mesocarp. *F*, fragment of pulp of mesocarp. *G*, fibres *H* and *ie*, inner epidermis of endocarp ; *ol*, oil droplet All × 240.

(*b*) *Histology and Microscopical Morphology* This is valuable both
many adulterants
calcium oxalate
richomes. Thus
surinam quassia is recognised by the absence of calcium oxalate and
varieties of senna
many adulterants
e stomatal index ;

rhubarb and ginger by their non-lignified vessels; Japanese chillies and fruits of *Capsicum annuum* in powdered cayenne pepper by the cells of the epidermis of the pericarp and varieties of aloes by the presence or absence of crystals of aloin. See details under drugs named.

(c) *Microscopical Linear Measurements.* The diameter of starch grains will distinguish varieties of ipecacuanha and also distinguish cassia bark from cinnamon and will detect senna stalk in powdered senna leaf. The length of the stomata in leaves of *Barosma betulina* will exclude leaves of other species of *Barosma*, the diameter of phloem fibres will detect cassia in cinnamon and the width of the vessels helps to detect clove stalks in powdered cloves. Measurement of diameter is also a valuable feature for the identification of commercial starches and for the detection in them of foreign starch. The height of the sclerenchymatous cells in the testa of cardamom will indicate the presence of certain inferior varieties (Fairbairn, 1015).

(d) *Solubilities*, especially exceptional behaviour towards solvents, are useful for the examination of many oils, oleo-resins, etc. Examples of peculiarities are the solubility of colophony in light petroleum; the solubility of balsam of Peru in solution of chloral hydrate; the solubility of castor oil in half its volume of light petroleum and the turbidity produced with two volumes of the solvent; the solubility of balsam of Peru in an equal vol[illegible]ol, 90 per cent., and the production of [illegible], and a similar behaviour of copaiba [illegible] petroleum.

(e) *Qualit[illegible] Chemical Tests.* Most of these tests are colour tests which are specific for certain substances. Examples are Halphen's test for cotton-seed oil and Baudouin's test for sesame oil in olive oil; the test with acetic and nitric acids for Gurjun balsam in copaiba; the copper acetate test for colophony which occurs as an adulterant for balsams, resins and waxes. The iodine test for starch will immediately distinguish Persian and Smyrna tragacanth, sterculia gum and carob gum. General tests for alkaloid, anthraquinone derivatives and cyanophoric glycosides are all of great value.

(f) *Physical constants* such as specific gravity, optical rotation, viscosity, refractive index are especially valuable for oils and fats, oleo-resins, balsams and similar substances.

(g) *Ultra-violet Light.* Many drugs fluoresce when the cut surface or the powder is exposed to ultra-violet radiation, and it is a useful routine procedure to examine in ultra-violet light all material upon which one is required to report. For a few drugs ultra-violet light will give information which cannot be obtained by other means. For example, some pieces of rhapontic, Indian and Chinese rhubarb are very difficult to distinguish with certainty and the difficulty is much increased when they are powdered. Examination in ultra-violet light gives such marked differences in fluorescence that the varieties can be easily distinguished. A similar position exists with respect to the roots of *Derris elliptica*, *D. malaccensis* and *Lonchocarpus nicou*, and these again can be distinguished by their characteristic fluorescence; for details see the individual drugs.

To a certain extent the results can be made quantitative. With unground rhubarb or derris the pieces in a mixture may be sorted into

varieties and the amounts determined. With powders one can often give some approximate result by comparing the specimen with mixtures of known composition.

not exhibit a similar fluorescence.

Tests more especially useful for judging quality are those that determine the amount present of certain specified structures or constituents.

(*h*) *Processes of assay* for alkaloid, resin, glycoside, vitamins or other constituent. Examples are the assay of total alkaloid in belladonna herb, the strychnine in nux vomica, the total alkaloid and non-phenolic alkaloid in ipecacuanha, the resin in jalap, the cardiac activity in digitalis and the vitamins in cod-liver oil. The results obtained will detect the presence of inferior or exhausted drug and, by proving absence of the assayed constituent, will suggest complete substitution of a worthless article. Tests of identity made upon the purified constituent extracted in an assay will confirm the nature of the drug under examination or may afford information suggesting irregularity or substitution.

(*i*) *Yield to solvents.* This provides a process of assay for drugs, such as linseed, which contain fixed oil as an important constituent,

upon the drug itself, as happens when colocynth seeds are mixed with

of tolu, catechu, etc.

(*k*) *Ash.* The determination of ash is useful for detecting low-grade products, exhausted drugs and excess of sandy or earthy matter; it is more especially applicable to powdered drugs. Different types of ash figures are used such as total ash, acid insoluble ash and water soluble ash. A total ash figure is useful to exclude drugs which have been coated with chalk, lime or calcium sulphate to improve their

oxalate, sometimes in large amounts and the amount is often very variable. A total ash therefore may vary within wide limits for specimens of genuine drug as it does in rhubarb, where the recorded values for total ash range from 8 to 40 per cent., a variation due to differences in the content of calcium oxalate; the total ash is therefore useless to detect earthy matter adherent to such a drug. Since, however, the calcium oxide or carbonate, yielded by the incinerated

can obtain evidence of the presence of excessive earthy matter, which is likely to occur with roots and rhizomes and with leaves which are densely pubescent, like those of foxglove, or are clothed with abundant trichomes secreting resin, as in henbane, and tend to retain earthy matter splashed on to them during heavy rainstorms.

The water-soluble ash is used to detect the presence of material exhausted by water and is used more especially for tea leaves and ginger rhizome. The total ash of ginger varies from about 2·5 to 6 per cent. and the water-soluble ash from 1·9 to 3·0 per cent.; for spent ginger, exhausted by water, the total ash is from 2 to 4 per cent. and the water-soluble ash from 0·2 to 0·5 per cent. The water-soluble ash is therefore subject to a much greater reduction than is the total ash and is therefore used as an important indication of the presence of exhausted material substituted for the genuine article; the water-soluble ash of ginger should not be less than 1·7 per cent. Tea has a total ash of about 5 to 7 per cent., a water-soluble ash of about 3·2 to 4·2 per cent.; exhausted tea has an average total ash of about 4·4, a water-soluble ash of about 0·7 per cent. and it is generally accepted that the soluble ash of genuine tea should not fall below 3·0 per cent. When examining tea a further check is usually applied by determining the alkalinity of the water-soluble ash, the result being expressed as potassium oxide (K_2O); this should not be less than 1·3 per cent.

(*l*) *Crude Fibre.* Determination of crude fibre by the method of the Ministry of Agriculture and Fisheries is used to detect excessive woody material. It is particularly useful to determine the presence of clove stalks in cloves, the crude fibre of cloves being about 6·2 to 9·8 per cent., while that of clove stalks is about 13·6 per cent.; good cloves should not yield more than 10 per cent. of crude fibre.

(*m*) *Quantitative Microscopy.* When chemical and physical methods are inapplicable, as often happens with powdered drugs, in certain instances one can determine the proportions of the substances present by means of the microscope. Starches or starchy drugs, when used as adulterants, can be determined by counting the number of starch grains per milligramme and calculating the amount from the known number of starch grains per milligramme of the pure starch or starchy material. Thus if spent ginger is the [illegible] knows that ginger contains 286,000 [illegible] the amount used [illegible] For leaves, the [illegible] measured and from know[illegible] area of the leaves concerned one can [illegible] the proportions present. If the leaf or starch is one for which a constant is not available, it is necessary to determine one by a preliminary experiment. Certain barks in powder can be determined by measuring the total area of fibre per gramme and calculating from known constants; when, for example, cassia is substituted for cinnamon, either wholly or in part, one can use the established data that powdered cinnamon has a mean area of 85 sq. cm. of fibres per gramme, and powdered cassia has a mean area of only 11·75 sq. cm. of fibres per gramme (Saher, 1940). For experimental details, see "Practical Pharmacognosy," by Wallis.

STANDARDS

It is important that drugs should be uniform in quality, both as regards origin and cleanliness and also with respect to the content of therapeutically active constituents. Such uniformity is necessary to ensure an expected effect when a particular dose is prescribed and also to assist the pharmacist in making galenicals which will always be of uniform strength.

Uniformity of quality is promoted by the use of standards which are numerical quantities by which the quality of commodities may be assessed. The information upon which standards may be based is obtained by a study of the genuine drug, the methods used for adultero-tion and the means adopted for the detection of adulteration. In proposing standards for crude drugs there are three sets of properties of the drugs which may be considered. The first comprises the structural form, the second concerns the constituents of the material, and the third relates to its physical characters; there are therefore three kinds of pharmacognostical standards in common use, viz., (1) structural standards, (2) analytical standards, (3) physical constants.

All standards impose limits and **structural standards** limit the amount of certain named parts of the organism concerned which may be included in the drug when they occur as a result of carelessness during the process of collection or preparation or both and they also limit the amount of other foreign structures consisting of materials deliberately added in partial or complete substitution of the genuine article, with a view to obtaining greater profits or to make up bulk. **Analytical standards** require the presence of minimum amounts of useful constituents, some of which are definite substances such as strychnine, quinine, cantharidin and balsamic esters, while others are less definite and include such materials as water-soluble extract, yield to alcohol, etc. A third type of material limited analytically is mineral matter and for this purpose a maximum limit is imposed in the form of total ash and acid-insoluble ash. **Physical constants** are properties such as density, refractive index, average mass of such plant members as seeds and starch grains.

The introduction of standards may create new and unforeseen difficulties. A standard for the amount of active constituent always tends to be a low one so as to include most commercial material of good average quality. As a result there may be a temptation to reduce all supplies of certain drugs to the low standard by blending poorer qualities with better. Such manipulation is more likely to occur with powdered drugs than with unground drugs, and the establishment of low standards with narrow limits for powders has led to undesirable results, chiefly because the standards set are considerably lower than the quality of a good commercial article. For example, it happens with certain drugs that during preparation the stems become almost entirely separated from the leaves and other parts and, when the analytical standard is so low that the stems contain sufficient active principle to comply with it, these stems, which would otherwise be waste material, have been powdered and sold as the powdered drug. The remainder of the drug, having a much higher content of active

constituent, can then be used by the manufacturer for the economical preparation of galenicals. One unfortunate result, therefore, of standardisation has been to contribute an important factor in the removal of the manufacture of galenicals and medicaments from the sphere of the individual pharmacist and to bring it almost exclusively within the province of the wholesaler.

FIG. 211. Woodcut from the *Ortus Sanitatis* 1491, representing the study of Materia Medica in the 15th and 16th centuries.

APPENDIX

CALCIUM OXALATE

Calcium oxalate is the substance which occurs most abundantly in plant tissues in the form of well-developed crystals. These crystals vary very widely in size and appearance and some explanation seems necessary to account for the great diversity they exhibit.

which are distinguished and in all the systems, e one or more axes of symmetry. The six systems are :—

1. **Cubic**, Isometric or Regular system, which has three equal axes, all at right angles to one another. A simple form is the cube.

2. **Tetragonal** or Quadratic system having three axes all at right angles to one another ; two axes are equal and are known as the lateral axes, while the third is shorter or longer than the others and is known as the vertical or principal axis. A simple type is the right square prism.

3. **Hexagonal** or Rhombohedral system has four axes, three of which are equal and in the same plane and at an angle of 60 degrees to one

n and at right

), named the hexagonal and rhombohedral systems respectively, making a total of seven systems instead of six.

4. **Rhombic** or Prismatic system has three axes, all at right angles to one another, but all unequal in length. A simple form is the right rectangular prism.

5. **Monoclinic**, Oblique or Monosymmetric system has three axes

orthodiagonal and that which is not at right angles to the principal axis is the clinodiagonal. A simple type is the oblique rectangular prism.

6. **Triclinic**, Doubly-oblique or Asymmetric system has three axes of unequal lengths and none is at right angles to another. An example is the doubly oblique prism.

Calcium oxalate is a dimorphic substance and its crystals occur in both the tetragonal and the monoclinic systems, so that a brief description of these two systems may be given.

Tetragonal System. As pointed out above, one of the simple forms

tips of the axes are united by triangular faces, one obtains a second

fundamental form, the double pyramid or tetragonal octahedron. Prisms and pyramids may be combined to give more complex forms and by truncation of apices still further forms are obtained. Association of several crystals in radiating adhering groups gives compound crystals more or less spherical in shape and known as cluster crystals. Also much elongation of the principal axis may take place, producing needle-shaped crystals; or the principal axis may be relatively very short, giving a broad squat crystal.

Crystals may be developed so that only half the possible faces are present; these forms are termed *hemihedral*. If alternate faces of a tetragonal octahedron are extended till they meet one another the new

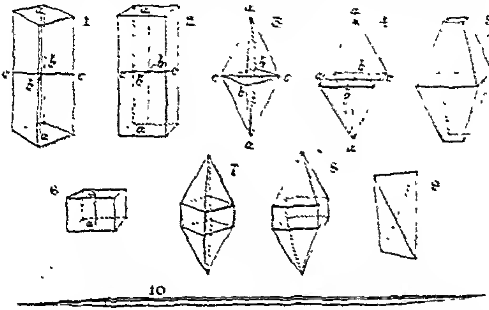

FIG. 212. Tetragonal system. 1. Right square prism of the first order. 2. Right square prism, second order. 3. Double pyramid (octahedron), first order. 4. Double pyramid, second order. 5. Double pyramid, second order, with truncated apices. 6. Right square prism having principal axis shorter than the lateral axes. 7. Short prism with pyramid on each end, first order. 8. Similar to 7, but second order. 9. Hemihedral sphenoidal crystal, developed from 3. 10. Narrow elongated prism with elongated pyramids, forming a needle. *aa*, principal axis; *bb* and *cc*, lateral axes.

form is a hemihedral crystal which has four faces each being an isosceles triangle. Since these four-sided crystals are wedge-shaped they are termed sphenoidal.

[illegible]

Hyoscyamus spp. The sandy crystals of henbane are hemihedral, being [illegible] sphenoidal crystals that have isosceles triangles for their faces.

Monoclinic System. In this system there are two series each of four simple elementary forms. In the first series the crystals are inclined towards the longer lateral axis and in the second series towards the shorter lateral axis. In each series there are the following elementary forms: (a) Oblique rectangular prism with four faces and

two rectangular enc
two rhomboidal enc
eight triangular fac
(*d*) oblique double
and a rhomboid ba
may be combined together as in the tetragonal system

py
infectoria and the apices of the pyramids may be truncated in some of the crystals. The same type of crystal is found in *Veratrum*, but the principal axis is enormously elongated giving an acicular crystal. In

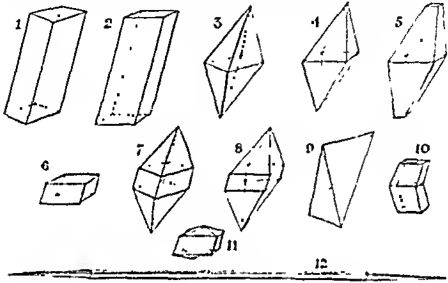

FIG. 213 Monoclinic system. 1. Oblique rhomboid prism. 2. Oblique rectangular prism. 3. Oblique double pyramid with rhomboid base. 4. Oblique double pyramid with rectangular base. 5. Similar to 4 with truncated apices. 6. Similar to 2 with short principal axis. 7. Short oblique rhomboid prism combined with two pyramids. 8. Similar to 7, but of the second order. 9. Hemihedral oblique sphenoid, developed from 3. 10. Twinned crystal developed from 2. 11. Short oblique prism combined with short pyramids. 12. Elongated narrow prism and pyramids, forming a needle.

the bark of *Quillaia Saponaria* a very wide prism is combined with very short pyramids and these crystals also frequently show the phenomenon of twinning, *i.e.*, they have the form which would result if a normal crystal were bisected across the prism and then one-half were rotated through 180 degrees. Similar twins are found in Jamaica quassia wood from *Picrasma excelsa*. The oblique rectangular double pyramid or octahedron is found in cubebs, the fruit of *Piper cubeba*, and if a number of these octahedra are united in radiating groups, with or without the addition of prisms, cluster crystals result, often with radiating points as in senna or with a mixture of points and prism bases as in the cluster crystals of rhubarb and stramonium.

Hemihedral or sphenoidal forms are also derived from the monoclinic

octahedra by the extension of alternate faces as in the tetragona system. The triangular faces of the crystals so formed are, however scalene triangles. The microcrystals occurring as sandy crystals in belladonna are monoclinic microsphenoids and are therefore different in shape from the sandy crystals of Henbane.

Calcium oxalate which crystallises in the monoclinic system has only one molecule of water of crystallisation, $CaC_2O_4.H_2O$.

The *great variety of habit* exhibited by crystals of calcium oxalate in plants is due therefore in the first place to the occurrence of calcium oxalate crystals belonging to two different crystallographic systems and secondly to the variations within each of these systems resulting from (*a*) the unequal development of the faces and axes of the forms represented in the several crystals, (*b*) to twinning of crystals, and (*c*) to adhesion of crystals together in groups.

It is often a matter of great difficulty to determine the exact crystallographic forms of the crystals by measuring their angles and by observing the effects of polarised light, consequently for descriptive purposes many non-crystallographic morphological terms are used in plant histology :—

1. Prisms or single crystals. A term applied equally to simple forms and twinned crystals which are comparatively large and well formed, as in quillaia, hyoscyamus, liquorice, etc.

2. Cluster crystals. These are aggregate crystals composed of numerous prisms or pyramids or both, which have grown together to form more or less spherical masses with projecting points and angles all over the surface, as in senna, stramonium, rhubarb, etc.

3. Rosettes. These are aggregate crystals having the appearance of a fairly large centre, which may be partly organic, from which the component crystals radiate and so nearly equal in length as to give a slightly toothed circumference. A good example is found in the small spherical crystals embedded in many of the aleurone grains of umbelliferous seeds. When focussed at about the central point they have a flat appearance and closely resemble rosettes; if made to roll over it is, however, immediately evident that they are spherical and not flat.

4. Acicular crystals. These are long slender crystals with pointed ends, usually found in bundles, as in ipecacuanha where the cells are devoid of mucilage, or as bundles embedded in mucilage as in the scales of the bulb of squill. Small scattered needles are found in the cells of the parenchyma of gentian root and of cinnamon bark.

N.B. Acicular crystals are sometimes termed raphides, but this term, although originally applied to needle-shaped crystals, became extended to any form of crystal found in plants such as crystals of rhubarb or stramonium, the different types being distinguished as acicular raphides, sphere raphides, etc. It is therefore better to reject the term raphides for needle-shaped crystals and to use the description acicular crystals.

5. Microcrystals or sandy crystals. These are very minute crystals often occurring in a cell in large numbers, frequently completely filling the cell. The form of the individual crystals may vary in different plants; in cinchona the sandy crystals are small prisms, in belladonna they are monoclinic microsphenoids, and in hyoscyamus they are tetragonal microsphenoids.

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LONDON AND TONBRIDGE